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CHEMICAL ENGINEERING PROGRESS

DECEMBER 1959

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page 39

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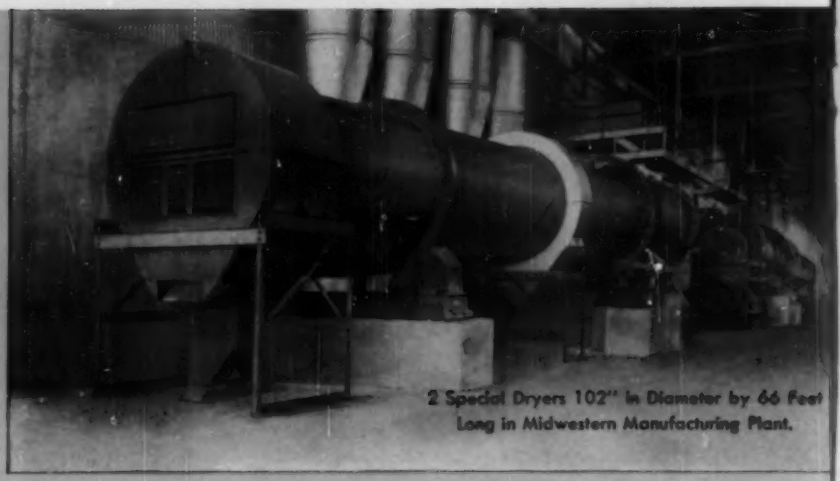

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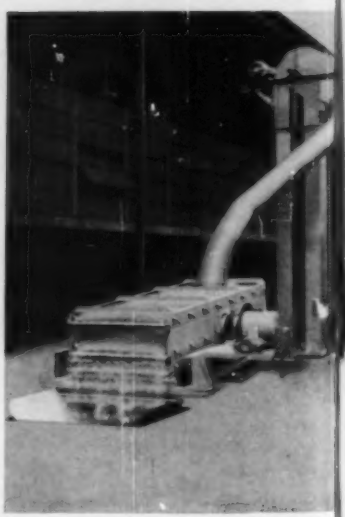

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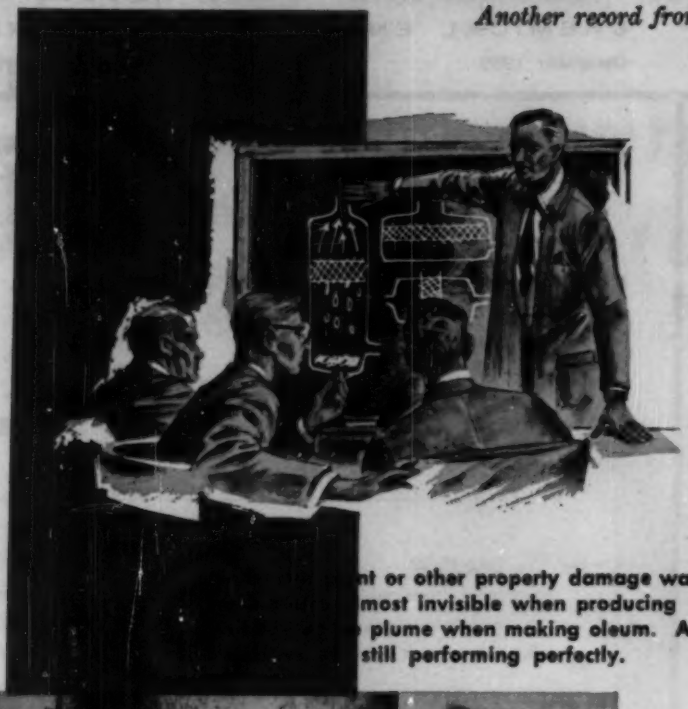

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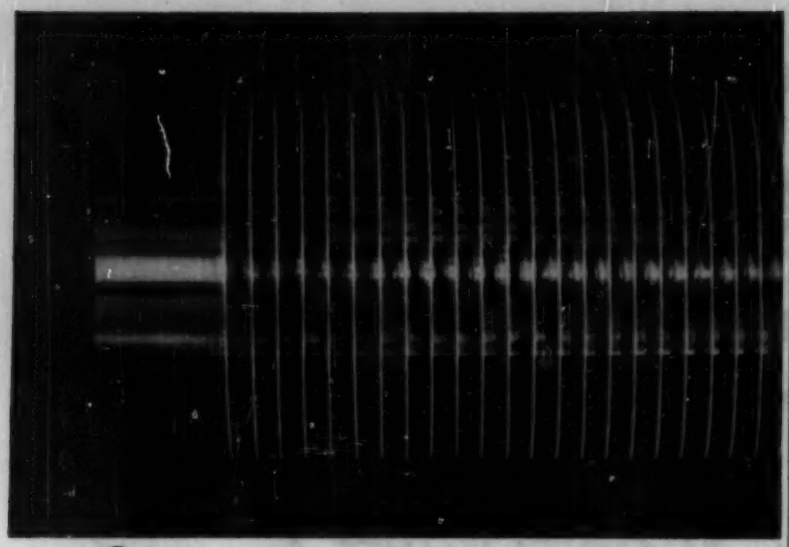

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about our authors

According to **D. A. Dahlstrom**, co-author along with **C. F. Cornell** of (*The Belt Filter Concept*), the filter itself started with a project at Michigan State University on composting sewage and garbage. Eimco donated the equipment, and supplied the first model of the Eimcobelt for initial field work. Cornell has worked on the development of the filter from its infancy, and also from his own professional infancy. He was assigned to the project right after coming out of

Cornell Dahlstrom Maddox

Northwestern with a BS CHE. in 1954, and has followed it through ever since. Dahlstrom is director of Research and Development at Eimco, a department he set up in 1953. For a while he combined this post with one on the chem engineering faculty at Northwestern University, but gave up teaching in 1956. Dahlstrom is also director of Process Engineers, a company subsidiary.

A. E. Teetzel, F. M. Abbott, R. L. Maddox, J. A. Williamson's (*Screw Equipment-Temperature Problems?*) similar interests and background made it logical for them to come together as collaborators. Maddox is the only one of the quartet who is not with National Lead, Ohio. He does correlation and mathematical interpretation of data obtained by research groups at U.S. Industrial Chemicals' Research Center. Teetzel, section leader at National Lead, is also in

Abbott Williamson Teetzel

charge of the instrumentation development at AEC Feed Material Production Center. Previously, as assistant electronic engineer at Monsanto, he concentrated on nuclear radiation detection equipment, and process control instrumentation. Williamson was also with Monsanto as electrical engineer in nuclear radiation detection instrumentation. Abbott's background includes work on instrumentation de-

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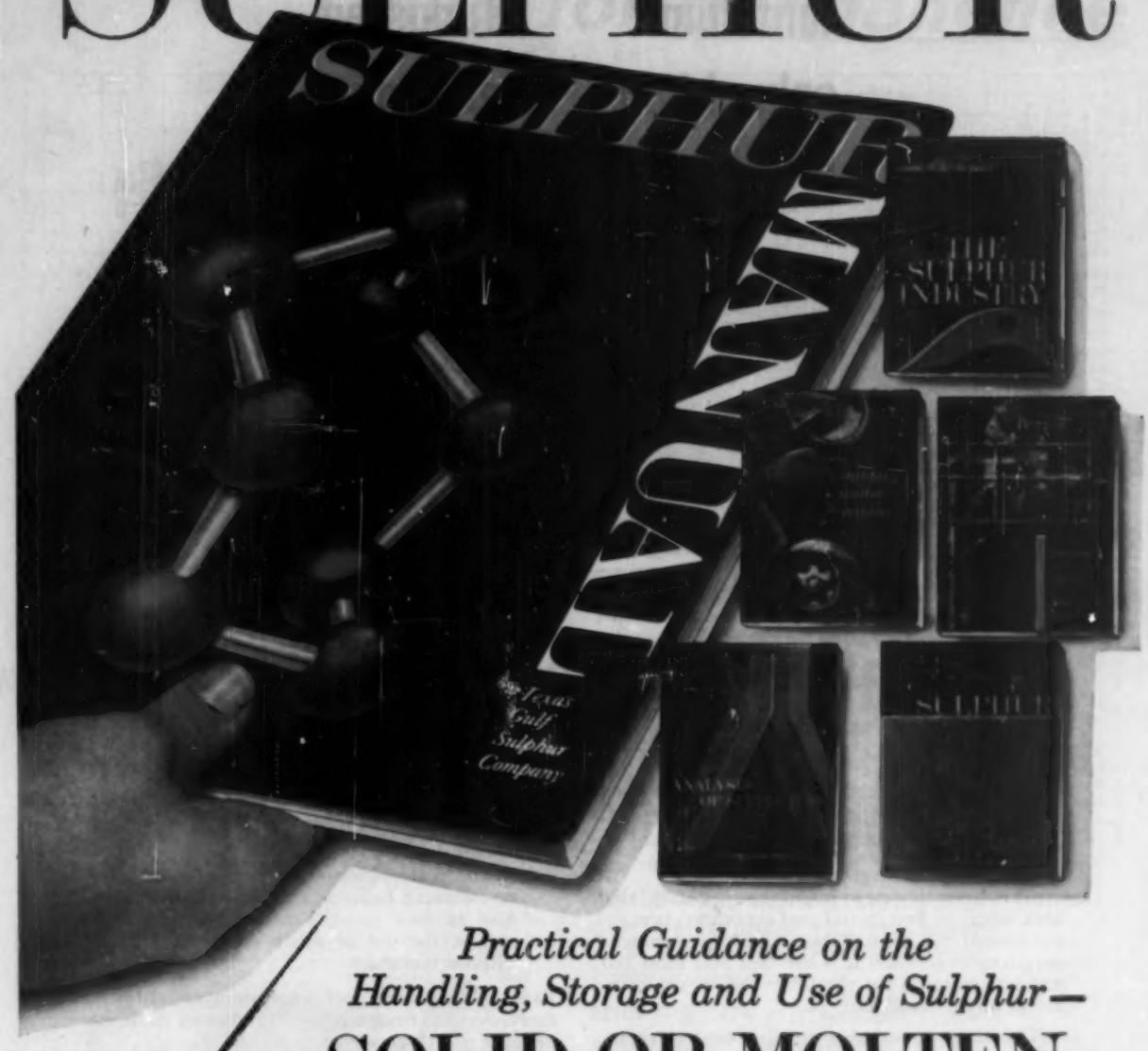
SULPHUR



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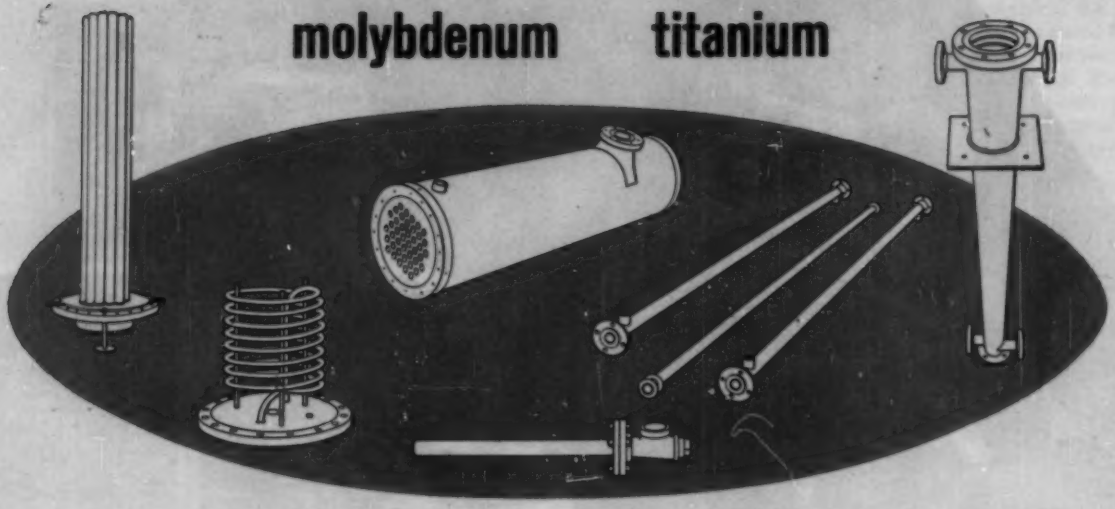

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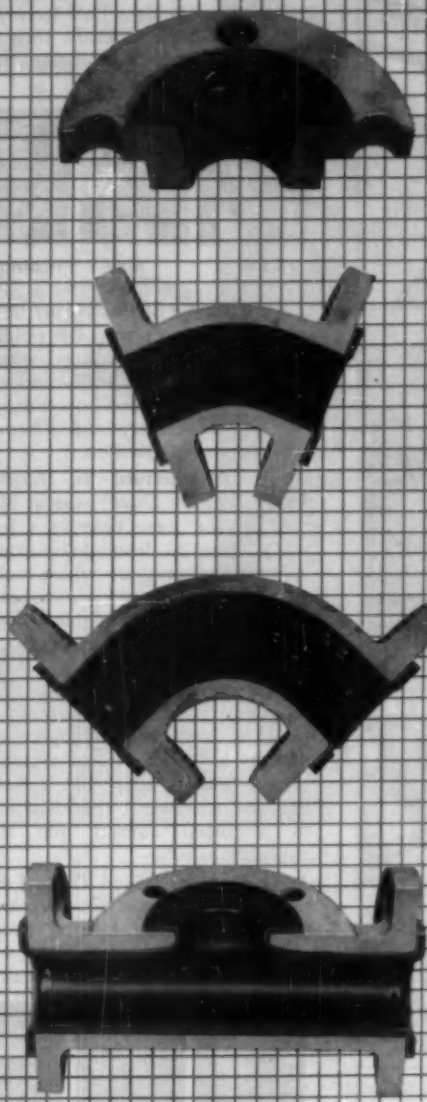

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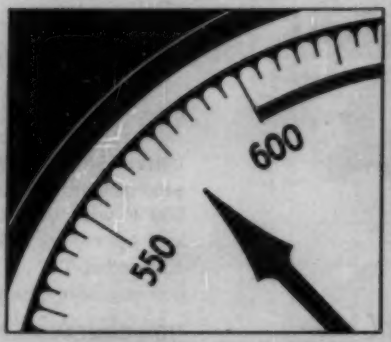

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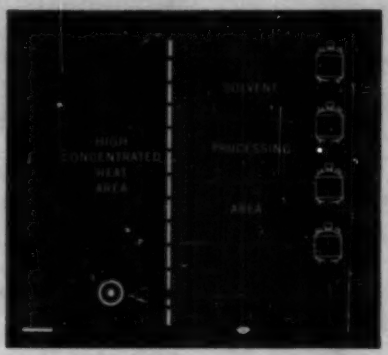

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Authors

from page 8

velopment at AEC Feed Material Production Center.

W. G. May (*Fluidized Bed Reactor Studies*) is now on a years' leave of absence from Esso Research, where he is a research associate. He is working for the Department of Defense in the advanced research projects agency. May holds a PhD from MIT, and a BS and MS from the University of Saskatchewan, where he also taught chemical engineering.

Rankin

May

Wrotnowski

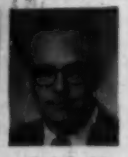
D. R. Rankin (*Radial Thrust in Centrifugal Process Pumps*) has published several articles, including papers on NPSH, mechanical seals, and sump design. He is at present chief engineer at Food Machinery and Chemical's Peerless Pump Division.

W. D. Weatherford, Jr. (*Imprinted Sector Rupture Discs*) was at Mellon Institute for some time as a fellow. While there he developed a combustion research program which included shock tube studies of hydrocarbon preflame reactions and engine studies of abnormal ignition phenomena. He has published in the fields of combustion, chromatography, distillation, thermodynamics, and mass diffusion. Now at Southwest Research Institute as a senior research engineer, Weatherford is engaged in combustion and heat transfer studies relating to advanced aircraft and missile applications.

A. C. Wrotnowski (*A Unified Filtration Assembly*) has done research in wool felt, bonded fabrics, filtration, and laminated plastics, in his eleven year association with American Felt

Weatherford

Connelly


Reinhold

in Connecticut. His paper on nonwoven filter media appeared in *CEP* in July, 1957.

Herman F. Reinhold, Jr. and Frank J. Connolly, Jr. (*Multiple-Effect Evaporation*) are engaged in process en-

continued on page 18

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Factory: Batavia, N.Y. Other Graham precision-built products: Heliflow Heat Exchangers, Monobolt Heat Exchangers, Deaerating Heaters, Surface and Barometric Condensers, Steam Vacuum Refrigeration, Aquamizer Evaporative Condensers.

For more information, turn to Data Service card, circle No. 2

WANT TO PUMP ANY OF THESE PROBLEM FLUIDS?

Chempump, the original "canned" pump, handles them all easily.

If you've got a problem handling volatile, toxic, explosive or other "tough" fluids, Chempump is your answer. This process-proved, maintenance-free pump can handle the tough ones with absolutely no leakage or contamination. Units available for system pressures to 5,000 psi . . . temperatures to 1,000 F. . . . capacities to 600 gpm.

Here's a pump that is built to a design evolved from years of experience in the "canned" pump field . . . many more years than any other manufacturer of similar pumps.

Only Chempump offers you proved operating performance . . . from thousands of installations in all types of services . . . plus experienced field sales engineering. Use Chempump to solve your fluid pumping problems. Write now . . . for "request for quote" data sheet . . . to Chempump Division, Fostoria Corporation, Buck and County Line Roads, Huntingdon Valley, Pa.

- Acetic acid
- Chlorine
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- Phenol
- Dowtherm
- Diethanolamine
- Dimethyl sulfate
- Heavy water
- Cyanides (toxic)
- Nitric acid
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- Nitrogen tetroxide
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- Formaldehyde
- Boron fuels
- Sodium hydroxide (less than 50%)
- Toluene diisocyanate
- Methyl chloride
- Mercaptans
- Ethylene oxide

Chempump combines pump and motor in a single, leakproof unit. No seals, no stuffing box. Most models U. L. approved.

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Finest in the field...*process proved*

For more information, turn to Data Service card, circle No. 34

LAPP ALL-SERVICE ACID PROOF VALVES

SOLID CHEMICAL PORCELAIN WITH **LAPP TUFCLAD.** ARMOR

Nothing defies corrosion like chemically inert porcelain. As made by Lapp, it is pure, dense, hard, close-grained, homogeneous and non-porous. Therefore there can be *no penetration—no crumbling* from capillary pressures—*no absorption* of liquids to contaminate later processing.

Resistance to corrosion and contamination is but part of the Lapp story; there's a *bonus* in that Lapp Chemical Porcelain costs considerably less initially than most corrosion-resistant alloys and lined equipment. *And* since it almost never needs maintenance or replacement, the economy of your purchase is further increased.

Security (protection of plant and personnel) is assured by the Lapp TUFCLAD armor. It consists of multiple layers of fiberglass impregnated and bonded to the porcelain with an Epoxy resin. Fiberglass has high strength and chemical resistance providing protection against impact damage and external thermal shock. TUFCLAD armor holds line pressures even should porcelain become cracked or broken.

***WRITE** for description and specifications for the entire line of Lapp Acid Proof Valves. Lapp Insulator Co., Inc., Process Equipment Div., 2307 Chestnut Street, LeRoy, N. Y.*

Lapp
CHEMICAL PORCELAIN

Y-Valves as shown, and Angle Valves are available in Lapp TUFCLAD Chemical Porcelain in ½" to 6" sizes. Also safety valves, flush valves, plug cocks, pipe and fittings (to 8" dia.) and special shapes.

For more information, turn to Data Service card, circle No. 21

Liquid Hydrogen . . . ultimate rocket fuel . . . is made at this new Air Force Tonnage Facility at West Palm Beach, Florida. At center is the heart of the unit—the "converter cold box", where mixed ortho and para Hydrogen are converted to a high percentage of para form, which is highly purified and liquefied for storage.

The storage tanks in the foreground hold the world's coldest fuel—Liquid Hydrogen, at minus 423°F, for use in developing new missile and space engines. Plant can be seen in background.

Air Products Capacity produces Liquid Hydrogen in tonnage quantities for the first time

This plant . . . designed, installed and operated by Air Products . . . produces Liquid Hydrogen on a tonnage basis for the first time. The same abilities that made this achievement possible can be put to work to supply you with important basic chemicals . . . gases and liquids such as Hydrogen, CO, O_2, N_2, syn gas, HCl, phosgene, ethylene and other intermediates . . . without capital investment on your part.

Air Products capacity . . . backed by unsurpassed engineering know-how and ingenuity in all phases of low temperature processing . . . can be counted on to supply your needs. For more information, and a discussion of your requirements, write or call Department C, Air Products, Inc., Allentown, Pa. Phone: EXpress 5-3311.

Air Products
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For more information, turn to Data Service card, circle No. 16

No Blinding

EIMCOBELT

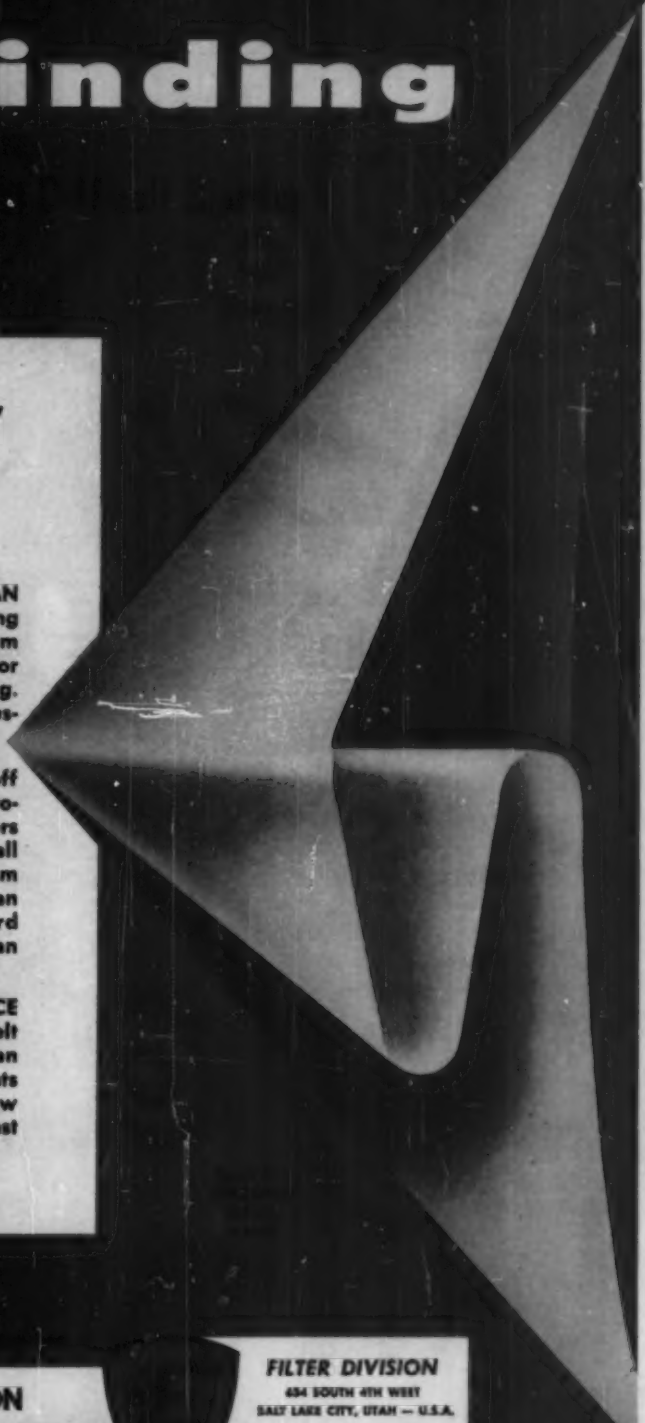
Continuous Belt Drum

FILTER

FILTER MEDIUM ALWAYS CLEAN . . . EimcoBelt filter's new operating principle removes the medium from the drum every filter cycle for cake discharge and cloth washing. No "time out" for cleaning is necessary.

HIGH CAPACITY — With no fall-off in filtration rate caused by progressive blinding, EimcoBelt filters operate at rated capacity at all times. Average production is from one-half to two times higher than average capacities on standard drum filters. Required tonnage can be obtained with a smaller filter.

SAVES TIME AND MAINTENANCE — Cloth filter medium on EimcoBelt filter can be changed by one man in less than 30 minutes. Cloth lasts longer because there's no air blow to billow cloth medium against scraper.



THE EIMCO CORPORATION

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RESEARCH AND DEVELOPMENT CENTER
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For more information, turn to Data Service card, circle No. 76

Life in these excited states...

"I've chipped off all the rust, Chief, but don't the walls seem kind of thin?"

Corrosion makes profits thin, too

If corrosion and contamination are eating into your profit margin, you need chemical-resistant equipment by American Hard Rubber Company. Look today to see where you can use Ace rubber and plastic pipe, valves, pumps, tanks and special parts. It doesn't cost... it pays!

Ace chemical-resistant rubber-lined steel pipe best for high-pressure, big sizes, or abrasives. Pipe, fittings and valves 1½ to 24".

Highly efficient *WE* pump. Capacity to 360 gpm. Cast iron, fully protected by top quality, chemical resistant hard rubber lining.

Design assistance and facilities for molding special fittings, pump parts, etc., of plastics or hard rubber. Also large hand-fabricating facilities.

Variety and quality to match *any* plastic piping. Riviclor PVC, Ace-Ite rubber-plastic, Parlan poly, Ace Saran, Tempron high temperature nitrile, hard rubber-lined steel.

ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY
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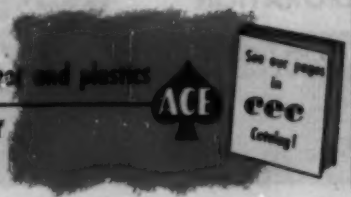

For more information, turn to Data Service card, circle No. 9

Authors

from page 12

gineering and design—Connolly as a supervisor at Hercules Powder, New Jersey, and Reinhold as senior engineer in the development group.

D. L. King (*Calcining Phosphate Rock*) is with the San Francisco Chemical Company in Montpelier, Idaho.

Production and sale of platinum petroleum reforming catalysts in Europe and the Middle and Far East will be done by a new company just organized in Hannover, Germany. Kali-Chemie-Engelhard-Katalysatoren G. M.B.H. was organized by Engelhard Industries, Newark, N. J. and Kalie-Chemie, AG, Hannover. The new arrangement will make available to refiners a choice of two types of platinum reforming catalysts under one license.

Three separate Dow operations will be grouped in the new Saginaw Bay Division, Bay City, Michigan. Included are the petrochemicals plant, producing ethylene, and butadiene; the polychemicals area producing polyethylene and polypropylene, and the Bay Refining Company. It supplies raw materials for the new division, in addition to its own sales in petroleum products.

Correction

In the article titled "Lamp-shade Filter Increases Efficiency of Batch Decantation Washing", by T. Kirby & J. Feorino, CEP, November, 1959, page 174, column 1, Equation 1 should have read as follows:

$$YN/YO = (1-F)^N$$

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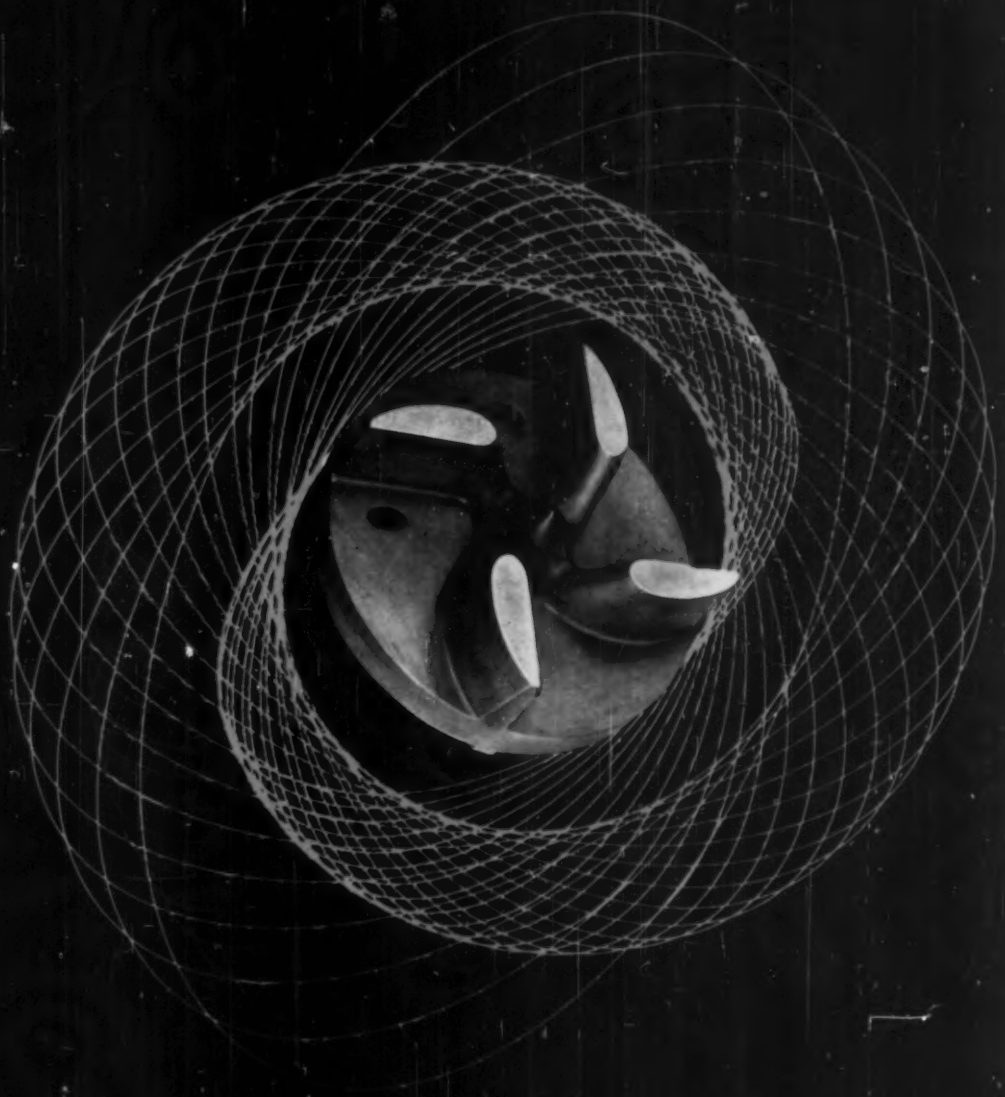

YOU CAN PAY MORE...
BUT YOU CAN'T BUY
A BETTER CORROSION RESISTANT PUMP

should have read as follows:

$$YN/YO = (1-F)^N$$

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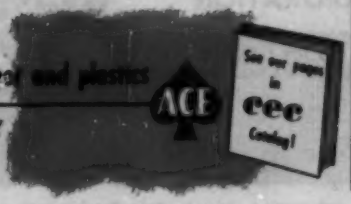
ACE processing equipment of rubber and plastics



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KARBATE TRADE-MARK **IMPERVIOUS GRAPHITE PU**

ECONOMICAL...AND UNSURPASSED IN CO

YOU CAN PAY MORE...
BUT YOU CAN'T BUY
A BETTER CORROSION RESISTANT PUMP

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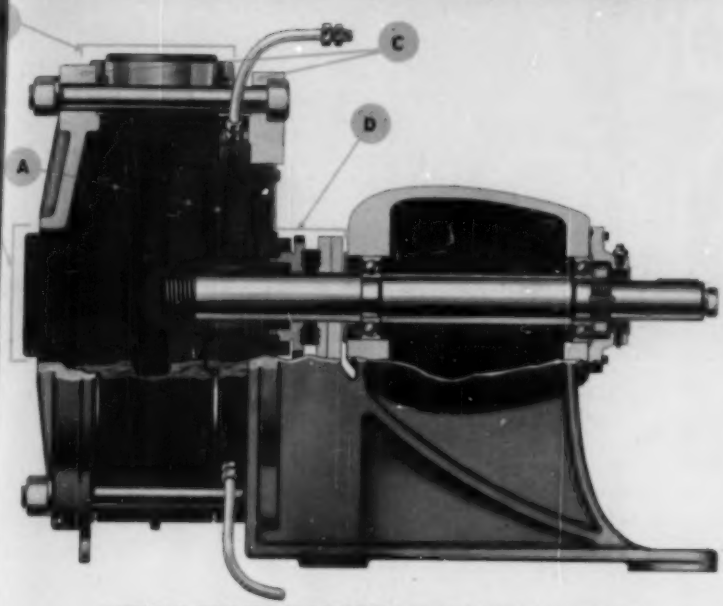
N CORROSION RESISTANCE!



TYPE C FRAME-MOUNTED CENTRIFUGAL PUMP

Cross-section shows typical "Karbate" frame-mounted pump recommended for heads to 120 feet—capacities to 1500 gpm. Adaptable to motors, belt drives or steam turbines.

A—Rugged "Karbate" impervious graphite wet-end parts

B—Compression type connections

C—Cast steel armoring

D—NATIONAL CARBON'S rotary seal arrangement

7 reasons why it will pay you to standardize on "KARBATE" Pumps

1 RUGGED CONSTRUCTION
All component parts are designed structurally to withstand normal—and many abnormal—conditions which occur in pumping and maintenance operations. The cast steel armoring and compression type connections help prevent damage from externally caused shocks and stresses.

2 UNSURPASSED CORROSION RESISTANCE
Few other pumps — regardless of price — can handle as wide a variety of corrosives as "Karbate" impervious graphite pumps. They are resistant to: **mineral acids** such as **hydrochloric, sulfuric, phosphoric; acid combinations** such as **nitric-hydrofluoric, phosphoric-sulfuric; chlorinated hydrocarbons; alkalies; and organic and inorganic compounds of all types.** In practically all of these corrosives, changes in temperature and concentration will not affect the corrosion resistance of "Karbate" impervious graphite.

3 WIDE RANGE OF MODELS AND SIZES
Twenty-five standard sizes of "Karbate" centrifugal pumps are available in both motor-mounted and frame-mounted types with capacities from 5 to 1500 gpm and heads from 15 to 120 feet. Motor-mounted pumps can be supplied with 1, 1½, 2, 3 and 5 horsepower motors. Frame-mounted pumps can accommodate motors up to 60 horsepower and can be adapted to belt drives or direct-coupled to steam turbines. Pumps can be operated at speeds up to 2400 rpm.

4 READY AVAILABILITY
All standard sizes and models of pumps and a large inventory of replacement parts are carried in stock for immediate shipment. In emergencies, parts can be shipped the same day order is received.

KARBATE
TRADE-MARK

IMPERVIOUS GRAPHITE P
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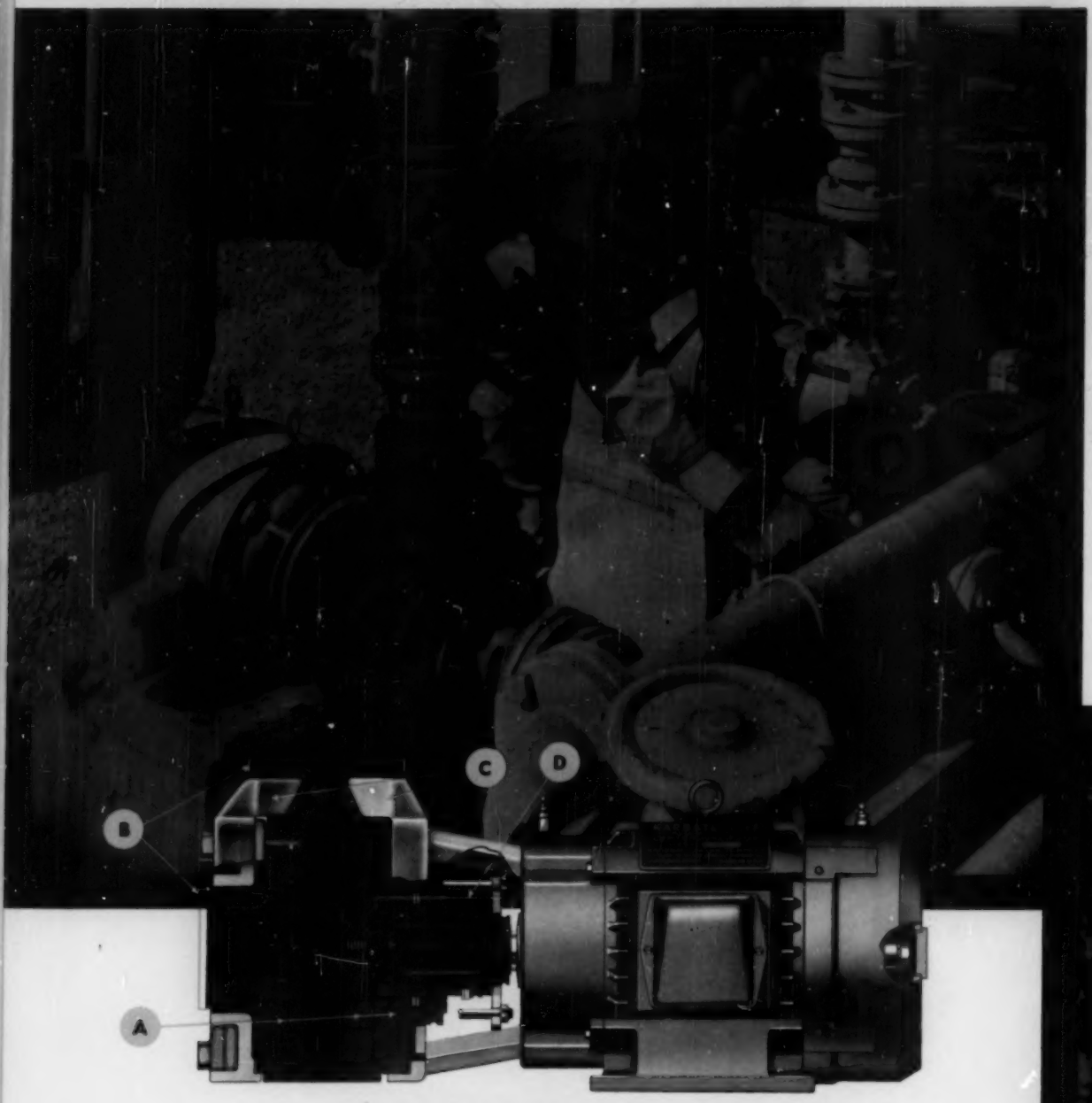

TYPE F MOTOR-MOUNTED CENTRIFUGAL PUMP

Cross-section above illustrates typical "Karbate" motor-mounted pump recommended for heads to 70 feet—capacities to 140 gpm. Letters refer to component features common to every "Karbate" pump.

A—Rugged "Karbate" impervious graphite wet-end parts

B—Compression type connections

C—Cast steel armoring

D—NATIONAL CARBON'S rotary seal arrangement

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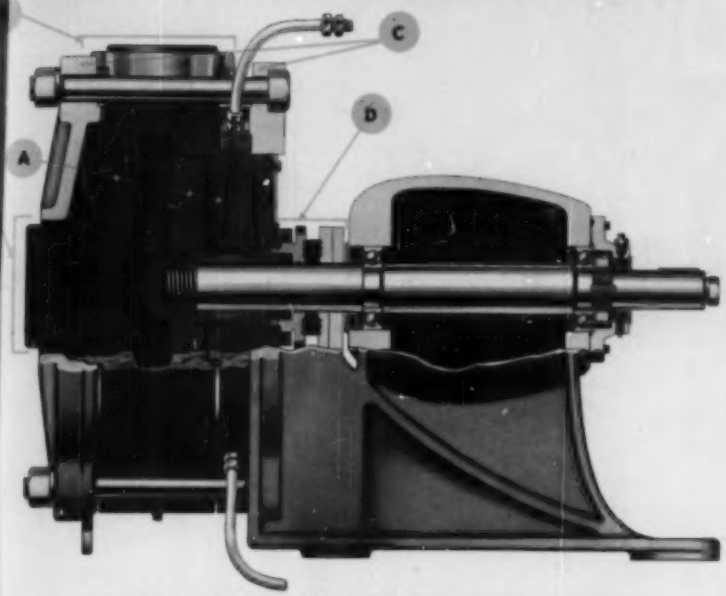
TE PUMPS ARE RUGGED...
IN CORROSION RESISTANCE!



TYPE C FRAME-MOUNTED CENTRIFUGAL PUMP

Cross-section shows typical "Karbate" frame-mounted pump recommended for heads to 120 feet—capacities to 1500 gpm. Adaptable to motors, belt drives or steam turbines.

A—Rugged "Karbate" impervious graphite wet-end parts

B—Compression type connections

C—Cast steel armoring

D—NATIONAL CARBON'S rotary seal arrangement

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Twenty-five standard sizes of "Karbate" centrifugal pumps are available in both motor-mounted and frame-mounted types with capacities from 5 to 1500 gpm and heads from 15 to 120 feet. Motor-mounted pumps can be supplied with 1, 1½, 2, 3 and 5 horsepower motors. Frame-mounted pumps can accommodate motors up to 60 horsepower and can be adapted to belt drives or direct-coupled to steam turbines. Pumps can be operated at speeds up to 2400 rpm.

4 READY AVAILABILITY

All standard sizes and models of pumps and a large inventory of replacement parts are carried in stock for immediate shipment. In emergencies, parts can be shipped the same day order is received.

5 PARTS ARE INTERCHANGEABLE

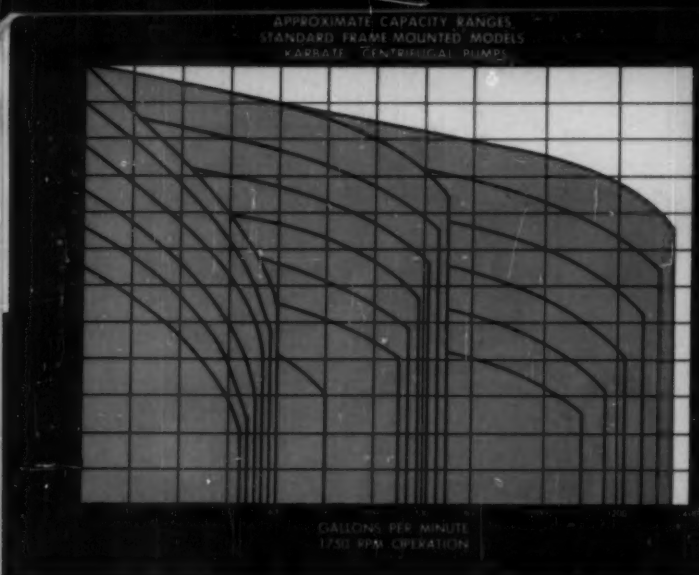
"Karbate" centrifugal pumps are designed for maximum interchange of parts. This keeps replacement parts stock at a minimum. All parts from the case cover back to the motor or frame are interchangeable within any model group. Impervious graphite is easy to machine. This makes possible the field turn-down of impellers to fit changed operating conditions.

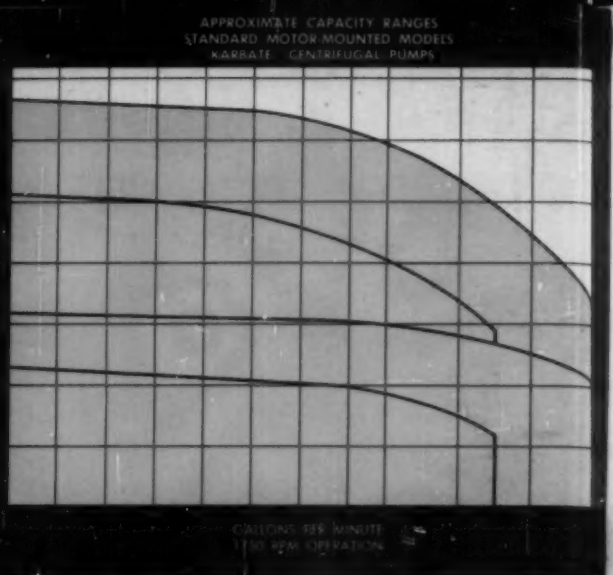
6 CHOICE OF SHAFT SEALING ARRANGEMENTS

NATIONAL CARBON'S rotary seal is standard on all "Karbate" centrifugal pumps. Pumps can also be furnished with "Durametallic", "John Crane" or "Chemiseal" rotary seal arrangements or stuffing boxes with external lubrication.

7 LOW OVERALL COST

The corrosion resistance of impervious graphite and the rugged construction of "Karbate" centrifugal pumps keep maintenance costs at a minimum. Furthermore, the initial cost of a "Karbate" pump is usually significantly less than that of a pump with equivalent corrosion resistance.





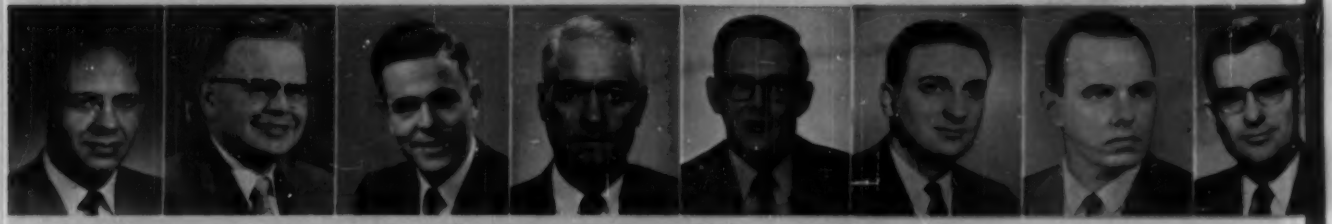
CAPACITY RANGES OF "KARBATE" CENTRIFUGAL PUMPS

These charts show the approximate head and capacity ranges of "Karbate" pumps. The lines on the charts are characteristic of the individual standard models. In the frame-mounted type C pump, higher capacities and heads can be obtained by increasing speeds to a maximum of 2400 rpm.

NATIONAL CARBON'S FIELD ENGINEERS WILL HELP YOU USE "KARBATE" PUMPS

NATIONAL CARBON'S eight field engineers call daily on the chemical and allied industries throughout the country. They are qualified and experienced to recommend the best corrosion resistant pump for your specific installation.

In addition, they will be glad to demonstrate to your production and maintenance departments the installation, operation and maintenance practices for "Karbate" impervious graphite centrifugal pumps.



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Litho in U. S. A.

High polymer market—8 billion pounds plus by '65

Chemical market researchers see polyethylene, vinyls topping the billion pound mark this year, admit new polymers will cut into present markets but over-all result will be a boom.

It took twelve experts two days to cover the major end uses for the growing high polymer field at Chemical Market Research Association's recent Chicago meeting.

Concensus: present large volume markets—fibers, film, coatings, containers, foams—will show good gains, in some cases are poised on the edge of a big breakthrough; smaller volume markets—elastomers, construction, specialties—can make rapid gains provided some big obstacles are overcome.

There will be no appreciable *drop* in the use of any plastic, including such old work-horses as the phenolics. This was the negative optimistic report of macromolecule scientist Herman Mark of Brooklyn Polytech. The growth rate will vary widely, and the newer polymers will, of course, grow in use more rapidly. Basic monomers will be cheaper and more available as a direct result of advances in petrochemical methods. The more distant future, according to Mark, holds promise of endless new polymers, with the goal in all case two-fold: linearity and regularity. Many addition reactions not possible today will result in a whole array of high-polymers. One of the most promising fields is that of the inorganic chains based on silicon-oxygen, magnesium-oxygen, or aluminum-oxygen bonds.

The general report on the present new polymers is, briefly: high-density polyethylene on the edge of a big jump, polypropylene farther off and with certain important defects to overcome (such as brittleness at 40°F and lower). Everyone is sure these problems will be solved, but the market men emphasize end-use problems, i.e. actual handling of the newer polymers by the established methods of the end-use industries.

The end uses

Film: A market this year of nearly a billion pounds, two thirds of a billion dollars, reports D. D. Lanning, DuPont. Packaging is the big field (600 million pounds), with polyethylene having the lions share of the plastics film sales (180 million pounds), but cellophane still far out in front (400 million pounds). Cellophane, with its smooth machine performance, will take a lot of beating. Non-packaging uses absorb 300 million pounds, primarily supplied by polyethylene and PVC. Industrial uses are expected to reach 600 million pounds by 1965, mostly polyethylene, polyesters, and vinyls.

- **Containers:** (Self-supporting containers made primarily of plastics.) A total of 91 million pounds in 1958, an estimated total of 250 million pounds by 1965 (C. Eustace, Plax Corp.). Polystyrenes and low density polyethylene lead the way. High density polyethylene is set for a big jump into the rigid bottle field. Consumption is still small compared to glass and metal, will remain so until pressure packing and heat filling can be handled which does not appear to be in the near future.

- **Coatings:** Allied Chemical's M. H. Bigelow listed 20 major polymers used in coatings. Lions share goes to alkyds, although these have "inherent weaknesses" and will grow at a slower rate unless a better alkyd emulsion is found. Consumption of all paints in 1958 was 654 million gallons, alkyds accounting for 351 million. Prediction for 1965 is 880-930 million, depending which survey is followed, with alkyds taking only 420 million.

- **Fibers:** Big job here is to break into cotton market, according to C. W. Bendigo, Werner Textiles Consultants. Present consumption (excluding hosiery nylon): nylon—330 million lbs./yr. (120 million in tire cord); acrylics—175 million lb./yr. production, mostly wool substitute staple, not all used; polyester staple—130 million lb./yr. production capacity, not all sold; polypropylene, other polyolefins—no olefin fiber a commercial success yet, but soon will be major. Big problem here is not monomer or polymer cost but selling, opening markets.

- **Elastomers:** So called "natural synthetics" are on the way, but, said K. Greene, Goodrich-Gulf Chemicals, the problem is still the isoprene supply —and price. Butadiene is cheaper, but polybutadiene rubbers have problems. However, polyisoprene and polybutadiene rubbers will be needed in considerable volume by 1965. Polyethylene and polypropylene rubbers are not significant now, probably won't be even by 1965, but with the very low monomer price work is sure to be done on them.

- **Construction:** A lot of publicity, little volume (T. A. DeMarco, Monsanto). About 1 million pounds used in 1958, compared to 100 billion pounds of cement, 85 billion pounds of lumber, and 20 billion pounds of steel. Problem is the attempt to use plastics in building designs based on the older materials. Plastics cannot replace steel, wood, or cement in present styles of building. What is needed to open this market is to change styles of buildings, educate architects, designers, underwriters, etc.

- **Foams:** Good sized and growing. Polystyrene foams lead the rigids by far, urethanes moving up fast in flexible foams. Total potential market by 1965—322 million cu. ft. Total expected sales by 1965—205 million cu. ft.

- **Specialty plastics:** Where the properties needed are so important that price does not deter, these plastics will hold their place, but volume is low, will stay relatively low.

The facts of life in Mexico

Coming chemical boom will offer big profit opportunities in Mexico, but there are pitfalls for the foreign and Mexican investor alike.

"Mexican chemical industry development has barely begun and the next ten years will witness a rate of growth several times greater than has occurred during the past decade," said recently Frank B. Loretta, president and general manager of Du Pont, S. A. de C. V. Cia. Mexicana de Explosivos.

The Mexican gross national product has tripled in the past twenty years, points out Loretta, and in the last decade it has averaged more than 6% annually, about twice the present annual rate of growth of the population. At the same time, demand for electricity has been growing at an accumulative rate of 11% per year.

Direct U.S. investment in Mexico for the process industries, only $22 million in 1943, increased to $400 million by 1957. Total foreign private investment is estimated at about $1,200 million, three-quarters of which is of U.S. origin.

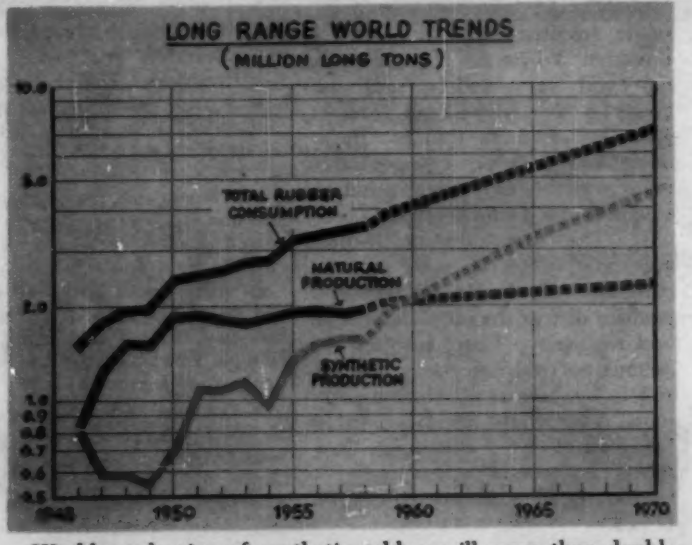
Investment prospects

What are the chances for profitable foreign investment in the coming Mexican chemical industry boom? Mexican supplies of basic raw materials are abundant, says Loretta, citing ample resources of petroleum, natural gas, sulfur, coal, zinc, lead, mercury, iron, salt, phosphate rock, fluorspar, naval stores. As Loretta sees it, prime opportunities will be in organics, as yet poorly developed, and in non-basic petrochemicals which, under the Government plan, will be left to private industry.

All will not be clear sailing for foreign investors, however, warns Loretta. The tendency is toward encouragement of more Mexican capital participation in all new ventures—in some industries, the law already stipulates that ownership must be at least 51% Mexican. In addition, the tax bite can easily reach the 52% U.S. corporate tax rate.

Good plant sites can also be a problem, says Loretta. For instance, in the Mexico City area, where most of the existing chemical production capacity is now concentrated, the water supply is not good and waste disposal can be a major headache. Skilled labor is also in short supply, although unskilled labor is plentiful.

On the plus side, there are good local facilities for fabrication of a large variety of process equipment at costs considerably under U.S. prices. This, in conjunction with the fact that civil constructions and buildings are also much cheaper in Mexico, makes it possible to engineer and build a processing plant in Mexico at about 85% of the cost of an equivalent plant in the States.



World production of synthetic rubber will more than double in the next ten years, as production of natural rubber stays about at current levels, predicts George R. Vila, U. S. Rubber Co. executive. By, 1970, says Vila, world-wide rubber consumption is expected to increase by two-thirds to about 7 million tons. At the same time, natural rubber production can be expected to level off at 2 to 2.3 million tons annually, largely because of insufficient replanting, particularly in Iondonesia, presently the world's largest supplier.

Chemical industry growth rate will continue upward

Strongest push predicted in petroleum and natural gas-derived synthetics, but other chemical products also continue upward.

"Recovery in demand, production, and profits from the recession lows of 1958 has been impressive," according to a recent chemical industry study by Harris, Upham, New York brokerage firm. This year's production of industrial chemicals is expected to gain by about 18% over 1958, continues the analysis report. Volume in the plastics field is predicted to zoom by about 23% in 1959, while an even greater gain of close to 30% is seen in the cards for the noncellulosic synthetic fibers.

"For the longer term," says Harris, Upham, "it appears that chemical demand will continue to grow at its postwar rate of better than 10% annually on average. This compares with an average annual gain of about 4% in national output. Increasing use of synthetics, namely, plastics, synthetic rubber, and synthetic fibers, as replacements for natural materials is expected to continue at an accelerated pace as the population increases and natural materials become more scarce. It is in this latter segment of the chemical industry, mainly the petrochemicals, that the growth rate has been most pronounced in the postwar period. Synthetic organic chemicals, which are about 80% derived from petroleum and natural gas, have shown a rate of growth in the postwar years averaging about 16% annually."

No let-up in growth rate

The brokerage firm looks for no let-up in the growth rate of the U.S. chemical industry. Basis of its confidence is the fact that the overall gain in production of industrial chemicals in the period between 1947 and 1957 averaged 11.4% per year, compared to an average yearly gain of only 4.3% for the total national industrial output.

Backing up its prediction, Harris, Upham points out that dollar sales of seven leading chemical companies grew from $3.5 billion in 1950 to an estimated $6.6 billion for 1959, a rise of 90%. Profits after taxes during the same period are estimated to show a gain of about 56%. Cash earnings, (net income plus depreciation) however, have kept pace with sales, with an anticipated rise of about 88% in the 1950-1959 period. "In general," concludes the report, "the industry has maintained its profit margins before taxes and depreciation charges."

Russian thermoelectric device claimed to exceed theoretical effciency

Tass, Soviet news agency, reports that thermal efficiencies of almost twice the theoretical maximum have been achieved. No details of the device have been released to date.

Yttrium—key to high-temperature alloys?

By alloying a small amount of yttrium with AISI-type 446 stainless, workers at General Electric have come up with "an alloy whose oxidation resistance is as good at 2,500°F as is the alloy not containing yttrium at 2,000°F." The iron-chromium-yttrium alloy, reports GE, is readily cold-rolled and easily welded.

Victor Chemical becomes Stauffer division

Stockholder approval has confirmed the merger of Victor Chemical Works, major producer of phosphorus and its compounds, with Stauffer Chemical. Victor will be operated as the Victor Chemical Works division of Stauffer.

One hundred million more pounds of polypropylene

Lake Charles, La., will be site of a new Hercules Powder polypropylene plant to be designed for more than 100 million annual pounds capacity. Construction will get under way immediately, completion of the first 50-million-pound unit is scheduled for early 1961. Propylene feedstock will come from Petroleum Chemicals, jointly owned by Cities Service and Continental Oil. Decision to go ahead with the venture in the face of predicted possible oversupply of the new plastic (see Trends, CEP, November, 1959, p. 35), was based on "widespread market acceptance of polypropylene for use in film and fiber, as well as injection-molded plastic items."

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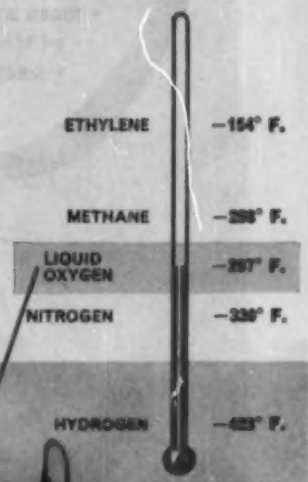
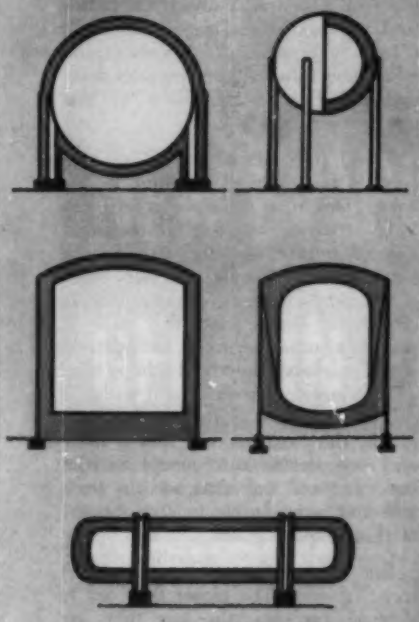


LOW TEMPERATURE STORAGE VESSELS



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Washington scope

Russian Bear Bears Watching

ALMOST NOBODY around Washington is willing to be quoted about the effect Khrushchev's recent visit had on the attitude of industry and government toward the export of chemical process know-how and equipment to Russia, but everyone likes to talk about it—cautiously and off the record.

Those having opinions are divided into four distinct groups—two in government circles and two in industrial circles. One group in government is concerned primarily with national defense; the other with international political relations. Washington industrial representatives are divided into those whose sponsors fabricate equipment, and those whose sponsors make and sell the end products of that equipment.

Those in government whose concern is for political stability in the world feel that somehow there can be a "stepwise" approach to the problem of selling capital goods to the Soviets—that Russian markets could offer compensatory opportunities to offset the competition that sale of process equipment might stimulate in world markets. They hold a hope that, as the doors open wider and wider to permit a greater and greater flow of goods, the Russians will find it more and more desirable to accept some of our products and that we, in turn, will find it profitable to accept some of their capital goods.

But all government people don't feel that way. The closer they are to defense agencies, the less they are inclined to go along with the international politicians. They say that if the Russians want know-how they should be made to spend the time and energy to develop it, or to try to get it by subterfuge. They agree that sooner or later the Soviet will get what it wants, but that, by then, we shall have developed better methods and better equipment. Government men who keep the international score observe that the type of processes and

continued on page 30

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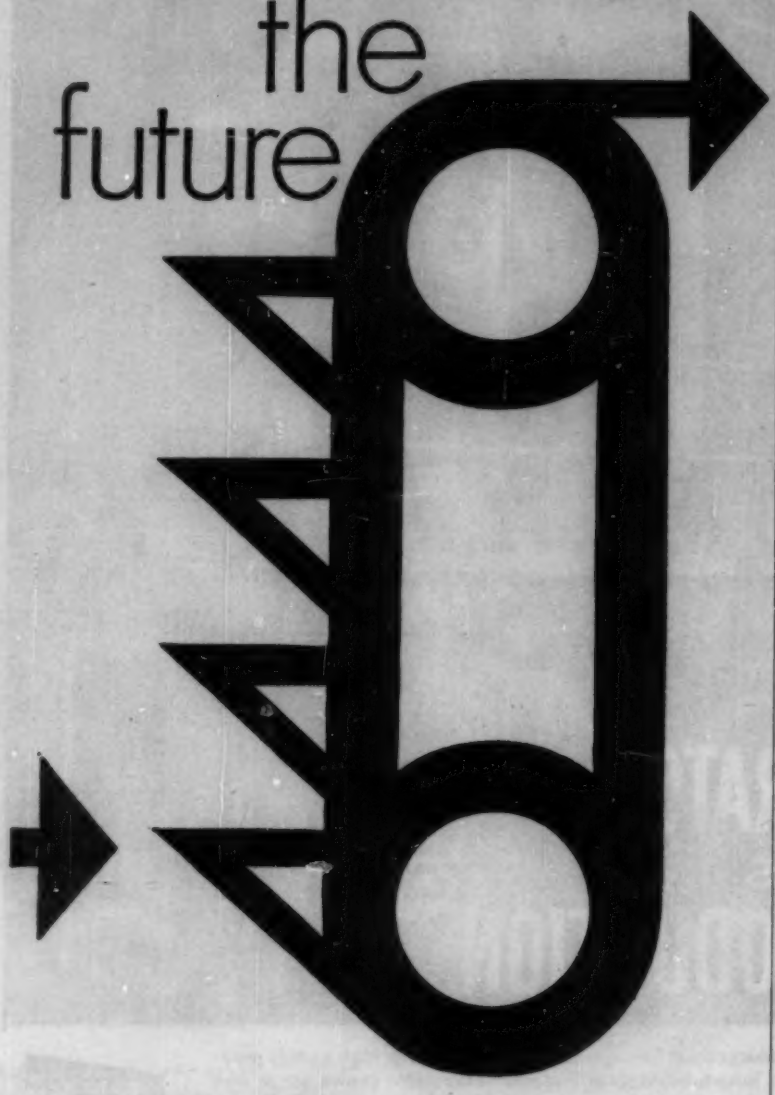
engineering the future



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Washington scope

from page 28

size of units that the Soviets want are a dead give-away. It is perfectly obvious to them, they say, that requests for plants with mammoth capacities based upon our very latest techniques establishes the Russian intention to dump goods on the world market, and to build up chemical military potential.

The opinion of Washington chemical company representatives is adamant. Principal concern of this group is not what will happen on the world market if the Soviets are equipped and instructed by our process plant suppliers—it's what will happen to markets right here in the U.S.A.

Washington process equipment representatives are inclined to think like the international politicians. They point out that we have not been successful in withholding know-how for production of military devices and that, furthermore, the Russians have established a technological capability equal to ours. Since, therefore, the Soviets will succeed by one means or another sooner or later, why not make the best deal we can—hold off letting them have our processes and equipment as long as we can, but sell it to them before they get it otherwise.

John T. Connor, Chairman of the Board of the Manufacturing Chemists' Association, sums up the attitude of the chemical business community this way, "I don't think there has been any basic change in our thinking as a result of Mr. Khrushchev's visit. I think there is still a strong feeling that it would be inadvisable to consider selling process equipment or process know-how to the Russians unless we get long-term reciprocal advantages. Neither Khrushchev nor any other Soviet official has suggested any such reciprocal advantages. I don't think we should have a closed mind on the subject, but most certainly should give it our attention in the event it is brought up."

So, while we can't prove that Mr. Khrushchev did anything during his recent visit to Washington toward directly opening the door for trade with Russia in chemical plant equipment, we can certainly conclude that he at least placed his foot firmly inside a door that was already creaking open. As Undersecretary of State Douglas Dillon said, "As you know, trade was very much in Mr. Khrushchev's mind during his visit, and it was discussed at Camp David." —*J. L. Gilman, Jr.*

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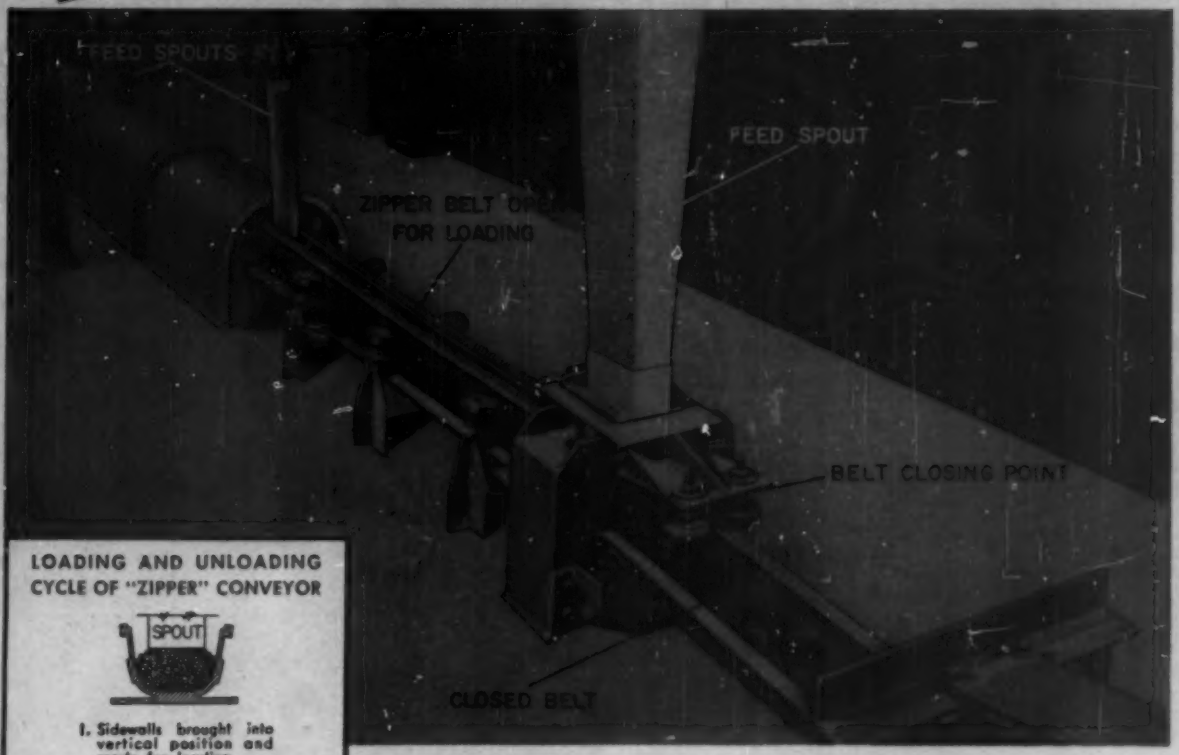
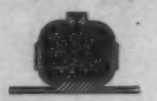


LOADING AND UNLOADING CYCLE OF "ZIPPER" CONVEYOR

1. Sidewalls brought into vertical position and ready for loading.



2. Flexible tube completely closed for conveying and elevating.

3. Rubber ZIPPER belt open for discharge, cleaning and return run.

Upper left unit closed and loaded. Lower right shows how belt is opened and closed by system of ball bearing rollers. (Rollers are mounted on a rigid framework)

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Background: *Compressing isobutane in refrigeration-system of alkylation plant of Petro-Tex Chemical Corp.* **Foreground:** *Cutaway of high-pressure seal of Cooper-Bessemer Type RD Centrifugal Compressor.*

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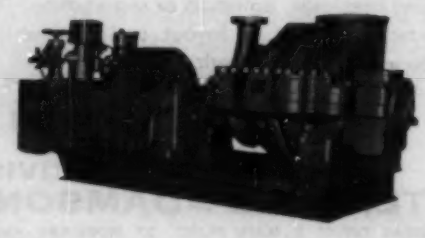

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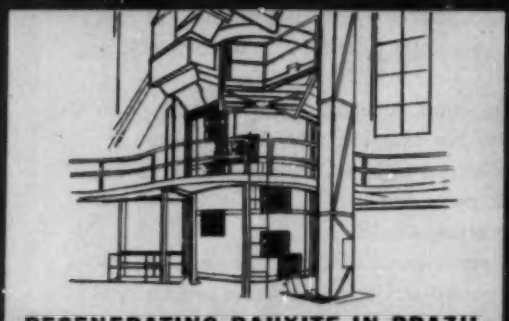

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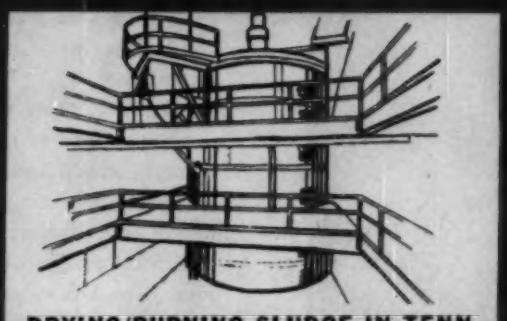

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DECEMBER 1959

.trends

Cuban league ground rules puzzling

Law No. 617 is the latest curve thrown at private industry by that famed knuckleballer, Fidel Castro. It's generally known as the "New Cuban Mining Law." Beyond this there's little agreement as to what it means to the companies operating on the volatile island—except trouble.

With much of its legal language clouded in ambiguities, such unsavory terms as expropriation and confiscation can easily be read into the law. To the discredit of the Cuban government, and the frustration of the companies, no effort has been made to clarify the law so that its implications can be clearly understood. Even its clearest point—the severance-export tax provision—is fraught with confusion.

Reregistering

The most ominous threat to ownership comes in the first four articles of the law. These begin innocently enough by requiring all companies to reregister their existing concessions. Article three throws a body blow at companies who for one reason or another are not operating their concessions at this time. The Minister of Agriculture can order "adequate commercial exploitation of the mines." This is regardless of whether or not the operation is commercially sound. The concessionaire has to begin production within 60 days after he receives the order to start—or else.

The "or else" aspect, while definite, adds to the general confusion. Specifically, the concession will be cancelled, and the property occupied so the state can proceed with production. The government will go the length of having the property appraised, but beyond that promises nothing. Whether the owner would be reimbursed for the seizure is left up in the air. Whatever the "appraisal" the payoff, if made, would certainly be in Cuban pesos, whose position in the money market is less than favorable. Whether you want to imply confiscation or expropriation, it is only half of the one-two punch.

The law goes on to its sixth article which tacks a 5% severance tax on the extracted minerals, and then says if they're exported the state's participation shall be 25% of the value. There's an ambiguity here for it's not spelled out whether the severance tax is over and above the 25% or not. In any event, the immediate 25 or 30% increase in cost means a staggering blow to the companies involved, if not actually pricing them out of the world market.

Market value

If a company, and many of them have substantial investments in Cuba, tries to make the most of it and live with the law rather than take a complete loss of its investment, it still doesn't know where it stands. The worthy revolutionary bureaucrats say the percentages are to be based upon the "highest annual average quotation registered in the world markets of all the minerals extracted from their concession." Try to figure that out! To boot, there are concentrates which are handled within companies on an integrated basis, never appearing on the world market as such. How to value these under Law 617 adds just one more question to the muddle.

Needless to say, the other marketers throughout the world who compete with the main Cuban products, such as nickel ore, manganese, copper, chromium, gypsum, and limestone can't help but take advantage of the situation. The disruption of the orderly marketing channels which are bound to take place can easily become a semi-permanent situation which would be one more millstone around Cuba's economy—a condition which apparently disturbs Señor Castro not the slightest. The relatively few American companies involved are in an unenviable position to say the least. The hidden implications, unfortunately, are not limited to these companies and this island.

Whether we like it or not, this knuckle-baller and his battery mate, brother Raul, have captured the headlines among our Latin American neighbors. A successful expropriation, seizure, confiscation—call it what you will—in Cuba could become a rallying point for other countries in which many, many American chemical companies have multi-million dollar installations. The political situation in many of these countries often makes it quite politic not to side with Uncle Sam.

From a practical standpoint, most companies can keep their fences mended and simply hope for the best. For there is little they can do directly but stand on the sidelines and see exactly what pitcher Castro is going to do in his "inning."

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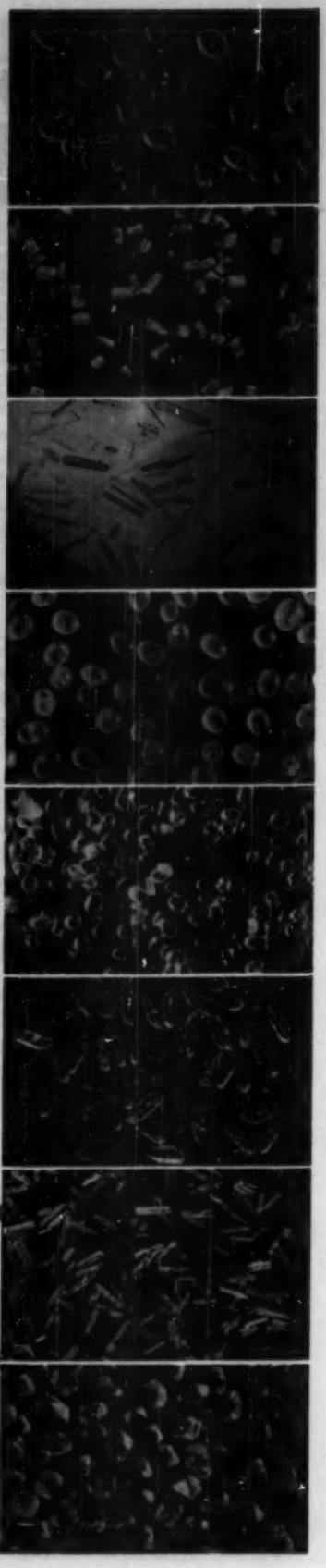

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opinion and comment

The Pattern Changes

It seems much longer than one generation ago that the United States was worrying about coal-tar dyes, organic chemistry, and pharmaceuticals; yet it is only forty years or so since World War I ended and the organic chemical industry began here. By 1919 we had a huge inorganic chemical industry but a quite unsatisfactory record in producing organic materials. This limitation caused great concern during World War I and afterward. Today, however, we not only have coal-tar dyes for wool, cotton, and silk, but we know how to dye many materials that were not even heard of in those days; our pharmaceutical industry is a model of excellence, with an extensive research program; and our organic industry can stand up with the best. The chemical industry has been alert, inventive, and successful, and it deserves all the commendation it has received for solving the problems thrust upon it. That it will continue to meet new problems is unquestioned, and speculation is already rife as to what the next forty years will bring. It is a sobering thought that we are a little more than one generation, too, from the beginning of the next millennium.

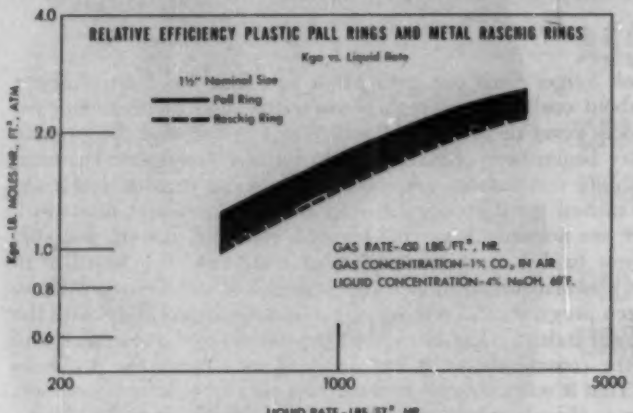
This column is to be no crystal-ball-gazing exercise, for not a glimmering of an idea about the future suggests itself—except one: that the pioneering literature, research, patents, and calculations that will spark the works of the twenty-first century are being generated now; that the minds that will use and extend them are being trained in our schools this instant.

How exciting the next forty years will be! And how different! And how much more will be demanded of all engineering, especially chemical engineering. The world of the computer is before us, and even now we are storing up ways to use nonclassical calculus, algebra, and geometery on these electronic marvels. Accepted now is the possibility of mathematical models that will design whole plants from basic information, that will predict physical, chemical, and physiological characteristics from molecular and spatial data. The electronic calculator will beat paths to another fantastic plateau of human achievement, and chemical engineering must be prepared to take them. Beginning attempts are already being made in this direction. The A.I.Ch.E. has a special committee and publication program on machine computation. Readers of CEP are familiar with the abstracts issued by this committee, which also published the first Computer Program Manual this month. At the San Francisco Meeting a special lecture on statistical techniques was sold out and may have to be repeated. Prominent members of the A.I.Ch.E. in the education field have embarked on personal study programs in mathematics and in computers in an attempt to keep themselves abreast of the field.

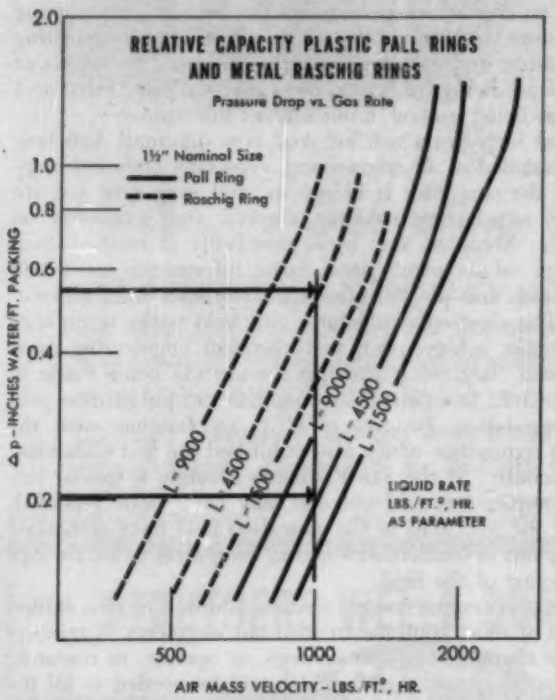
The challenge to chemical engineering is that, in addition to men skilled in the new techniques, it must continue to turn out engineers. Engineers are needed to staff the chemical field—to manage, to operate, to research, even to obtain the physical chemical data which will be needed to fill the mathematical maw. Chemical engineering and the chemical process industries, which it represents, will face in the next forty years an expansion that will dwarf that of the past forty years. It is a challenge that will require the complete attention and energy of the entire profession, beginning with the undergraduates and extending right up through management. And at every level there is no better place to explore and solve these problems than within the chemical engineers' professional society, the A.I.Ch.E.

F.J.V.A.

NOW PALL RINGS in PLASTIC



Kga data, obtained in one of our 30" experimental towers, reflects the much greater efficiency of plastic Pall Rings.



Pressure drop data likewise reflects the high capacity of plastic Pall Rings. For example, pressure drop through metal Raschig Rings at a gas rate of 1000 lbs./ft.², hr., and a liquid rate of 4500 lbs./ft.², hr., is almost three times greater than through plastic Pall Rings.

The remarkably efficient Pall Ring, first introduced on the American market in 1957, in metal, is now available in polypropylene and high density polyethylene;* in four sizes: ⅝", 1", 1½" and 2".

Pall Rings in plastic offer the same striking advantages of low pressure drop and high capacity at less than one-fourth the weight. (For example, 1½" Pall Rings in carbon steel weigh approximately 23½ lbs. per cu. ft. In plastic, only 4¼ lbs.)

Take a look at the graphs showing comparative efficiency data and capacity data for metal Raschig Rings and plastic Pall Rings . . . data prepared from test runs in one of our 30" diameter experimental towers. The differences stem entirely from the characteristics of the two rings. In the Pall Ring the inner projections of the wall become active working surfaces as opposed to the relatively "dead" inner wall of the Raschig Ring.

The conclusions are inevitable: tower volume can be substantially reduced by using Pall Rings (either metal or plastic) in place of Raschig Rings.

***On special order, Plastic Pall Rings can also be supplied in PVC and polystyrene.**

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F. M. Teetzel,
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R. L. Maddox

Technical Division,
National Lead Co.
of Ohio
Cincinnati, Ohio

Figure 2. Ceramo lead wires emerge from the shaft through compression fittings.

Screw equipment temperature problems?

Here's a sensitive temperature detection system which can help you whip them

One step in the series of operations required to produce a pure form of metallic uranium is the conversion of UO_3 to UO_2. This transition has been accomplished in screw reactors by reducing the UO_3 powder with hydrogen at elevated temperatures.

Maximum temperature limitations make temperature control exceptionally important, for if the powder is subjected to temperatures exceeding 1200°F its ability to undergo hydrofluorination in a subsequent process is hindered. Skin thermocouples peened to the reactor tube lacked sensitivity and this was reflected in production operations which often exceeded maximum temperature limits.

A more sensitive temperature detection system was constructed which has proven quite successful in this operation and which is applicable for measuring internal temperatures in most types of screw equipment.

In the reduction process, the horizontal tubular reactors have an I.D. of 16 in. and are 22 ft. long, the middle 18 ft. of which is enclosed by an electric muffle furnace. Solids are conveyed through the furnace by a ribbon flight screw 14⅜ in. diam. and 20 ft. long. Gas flow through the reactor is countercurrent to the solids flow. The screw was designed to agitate the solids sufficiently to effect the maximum contact between solids and gas.

In the new temperature detection system constructed, sheathed chromel-alumel thermocouples, 3/16 in. O. D., were used for the sensing elements.

. . . sheathed thermocouple material and the techniques used in this study make it possible to obtain internal reactor temperatures not previously measurable.

They consisted of thermocouple conductors surrounded by magnesium oxide insulation and sheathed with heat-resistant, corrosion-resistant metal. The metal sheath was drawn over the wires at the measuring junction and the assembly was welded together to form a grounded junction.

The reduction reactor screw on which the thermocouples were installed consisted of spiral ribbons supported by ribs radiating from a 6-in. O.D. hollow shaft made of 309 stainless steel. On the drive end, the hollow shaft and the drive shaft were linked by a universal coupling. On the idling end, a solid shaft, bolted to the hollow shaft, extended out of the reactor through a packing-gland and bearing assembly. Sheathed thermocouple lead wires were drawn through a boring in this shaft into the hollow screw-shaft, and thence out of the screw-shaft through compression fittings which formed a gas seal, Figures 1 and 2. The sixteen sheathed thermocouples were strapped to the outside of the screw-shaft and terminated with grounded hot junctions at desired intervals along the screw.

The thermocouple signals were transmitted through the lead wires to stationary terminals by means of a mercury pool commutator which was constructed to maintain continuity to sixteen wires (eight thermocouples). Any eight thermocouples (of the sixteen could easily be selected for continuous recording because of the use of eight double-pole double-throw switches installed between the lead wires and the commutator. Each lead wire from the double-throw switches was connected to a separate metal disc. The sixteen discs were mounted on the rotor shaft and electrically insulated from both the rotor shaft and each other, Figure 3. A lucite block, in which the rotor revolved, was machined to form an individual mercury pool for each metal disc. Terminals for the wires leading to a thermocouple selector switch, Figure 4, consisted of brass studs threaded through the side of the lucite and projecting into the mercury. Between the commutator shaft and the selector switch there was a gear linkage, Figure 5. The gear on the commutator shaft had one tooth, and the gear on the selector switch had a tooth for each pair of electrical contacts; thus, the selector switch moved to a new set of contacts with every revolution of the screw. The selector switch was wired in such a way that the output was transmitted from one thermocouple for two revolutions of the screw and was then shorted for another revolution after which the next thermocouple was connected in the circuit and the foregoing cycle was repeated. The output from the selector switch was transmitted to a curve-drawing (0 to 2500°F) strip-chart recorder. This instrument thus recorded the temperature from one thermocouple for two revolutions of the screw and then recorded room

Figure 1. Thermocouple lead wires exit from the reactor (through the shaft on the idling end of the screw). Below, exit detail.

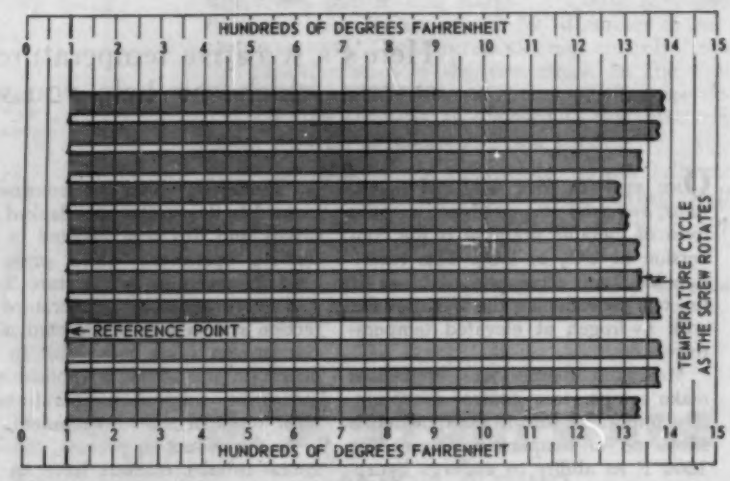
HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
REFERENCE POINT
TEMPERATURE CYCLE AS THE SCREW ROTATES
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
HUNDREDS OF DEGREES FAHRENHEIT

Figure 6. Experimental recorder chart.

Figure 4. Connector studs making contact with mercury pools in the lucite block.

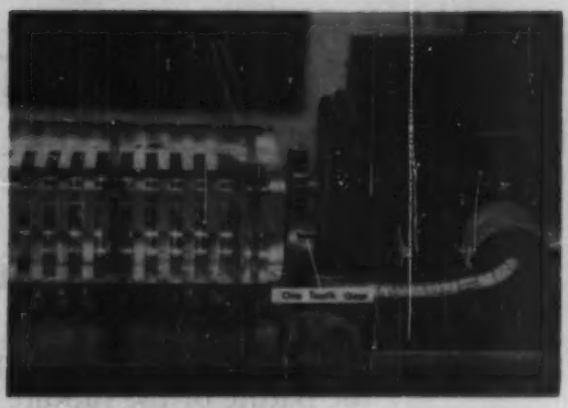

Figure 5. Gear linkage between commutator and the thermocouple selector switch.

Figure 3. Armature of the mercury commutator.

Figure 7. Thermocouple junctions protruding from the screw shaft.

temperature on every third revolution. As the screw rotated, the radial position of the thermocouple with respect to the powder bed changed continuously. For this reason, there was a slight cycling of the temperature indicated by each thermocouple; the temperature increased as the thermocouple approached the bed and decreased as it went further away. This can be observed in the recorder trace Figure 6.

The thermocouple hot junctions were installed on the first such screw constructed so as to be in thermal contact with the shaft. The temperatures indicated with this arrangement were tempered by the thermal mass of the shaft and were indicative of the general temperature gradient along the shaft, rather than indicating the powder bed temperature. Nevertheless, the information obtained from these thermocouples located, very closely, the area of high reaction rate, and from this information the effect of the operating variables upon this zone could be determined. Variations in the reaction rate of the UO_2 feed have been detected by changes in the measured peak temperatures.

Some of the thermocouples located in the zone of highest reaction (therefore in the zone of highest temperature) failed. Thermocouples with Inconel sheaths had been installed as an expedient to hasten application of the first special screw. Shortly after installation of the screw, activated UO_2 was used as the feed material. This caused the Inconel sheaths to corrode badly in the hottest zone, with resultant thermocouple failure.

A second installation was completed in which thermocouples sheathed with Type 310 stainless steel were used. At the same time, the thermocouples were bent so that the tips protruded from the shaft and the hot junctions were about 3 in. from the shaft, Figure 7. Thus, the measurements were not tempered to as great an extent by the thermal mass of the shaft, and the hot junctions passed through and were more sensitive to the temperature of the powder bed.

Failure of several thermocouples occurred just a few days after installation of this screw. Subsequent examination of the thermocouples revealed the sheaths to be severely corroded. Stresses set up in the metal sheathing during manufacture had apparently accelerated the corrosion since the sheaths had a regular checked pattern in many of the badly corroded areas.

The corrosion problems encountered were characteristic of this particular application, and it is not meant to imply that this material would have a short life expectancy under less severe conditions.

The introduction of sheathed thermocouple material and the techniques used in this project have made it possible to obtain internal reactor temperatures not previously measureable.

The equipment, with the exception of the failure of the thermocouple sheathing as described above, performed very satisfactorily and should be applicable to similar situations in the chemical industry where temperature measurements in rotary equipment are required.

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San Antonio, Texas

Imprinted-sector rupture discs

The development of a reproducible shock wave is influenced by the nature of the rupture disc fracture pattern. A technique was developed for preparing discs with controlled impressed radial defects, and having reproducible bursting patterns.

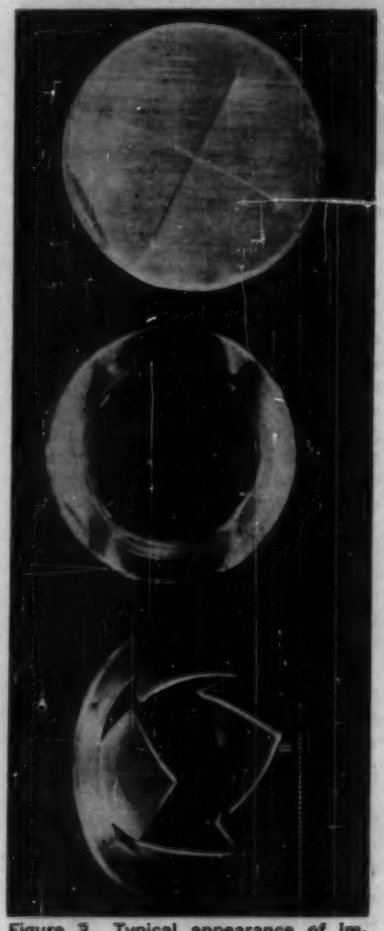

Figure 3. Typical appearance of imprinted-sector discs before and after rupture.

SHOCK TUBE techniques have been devised for studying a wide variety of natural phenomena, and new applications of such techniques are continually appearing in the literature. The use of rupture discs in the generation of shock waves has increased significantly in recent years. However, the existing technology of bursting-disc design and fabrication has been developed primarily for emergency, pressure-relief applications where downstream flow patterns are of minor importance. Hence, many of the modern developments in rupture-disc design are not amenable to shock tube applications.

The classical shock tube rupture disc is basically simple. It consists of a smooth sheet, suitably clamped between two flanges. Rupture is achieved by puncture of the stressed sheet, or simply by an increase in the pressure load beyond the yield point of the material. The types of fractures obtained with such bursting techniques are not easily reproducible (as discussed later) and the resulting variations in the compressed gas flow patterns significantly influence the nature of the generated shock waves.

A research program involving the design and use of a shock-wave-heated chemical reactor has led to the development of a new technique for preparing aluminum rupture discs having reproducible fracture patterns. In view of potential usefulness for other shock tube applications, it is the purpose of this article to discuss experimentally observed limitations of smooth-surface discs and to describe the development and characteristics of the new *imprinted-sector* rupture discs.

Smooth-surface rupture discs

A preliminary investigation of the bursting characteristics of 1-in. diam., smooth-surface, aluminum discs of various thicknesses yielded the rupture pressure correlation presented in Figure 1. This correlation reproduces the *maximum pressure* rupture data (which represent *complete* rupture *without peripheral shear*) with a mean deviation of 5%, and a maximum deviation of less than 15%. Many *other* points fell *well below* the indicated curve because of peripheral shear or because of premature, partial fracture at a pinhole. The experimental measurements of disc thickness and rupture pressure were made with micrometer calipers and a calibrated pressure gauge, respectively. The 0.5- and 0.7-mil aluminum sheets were furnished by Alcoa, and all other thicknesses were obtained from warehouse stocks.

The results shown in Figure 1 indicate that the *apparent* tensile strength of smooth-surface aluminum sheet decreases as a function of metal thickness. This decrease is appreciable for discs of less than about 4-mil thickness. For example, the bursting pressure of a ¾-mil disc is only 30% of that which would be predicted by dividing the bursting pressure of a 10-mil disc by a factor of 20. Hence,

the apparent tensile strength of a ¾-mil disc is only 30% as great as that of a 10-mil disc. This phenomenon probably results from variations in the physical nature of the aluminum sheet with changing thickness. Such variations are also apparent in Figure 2, which compares experimental bursting pressures for smooth-surface discs with results obtained by others (*1*). The curvature exhibited by the isobars in Figure 2 indicates that the apparent tensile strength is altered to some extent by the relative disc stiffness, which varies with the disc thickness-to-diameter ratio.

For the particular conditions and geometry employed, this preliminary study revealed that the fracture pattern is not reproducible when smooth-surface discs are ruptured without peripheral shear. It was also observed that in the higher pressure range (400-800 lb./sq. in. g.), the discs are prone to fail by peripheral shear rather than by tensile rupture; however, the use of soft aluminum back-up washers in the disc-holding flanges reduces the shearing tendency to a great extent. With smooth-surface discs, the presence of pinholes or structural inhomogeneities cause variations of the point of rupture initiation, as well as in the resulting fracture pattern. Many of these observed limitations could be overcome by changes in the design of the disc-holding flanges and by preselection, preforming, or pretreating of the rupture disc material.

Development of imprinted-sector rupture discs

To develop a laboratory technique for preparing shock-tube rupture discs having a reproducible fracture pattern, a study was made of discs possessing imposed structural defects. Early in this study, it was observed that shallow surface scratches, including scribed lines, had an unpredictable influence on the fracture pattern. It was also observed that when lines were scratched deeply enough to control the rupture patterns, the resulting rupture strengths for supposedly identical discs were erratic.

In view of this experience, a special tool was devised to provide a reproducible means for marking disc surfaces with *impressed* radial marks. When the tool parts are pressed together, a knife edge penetrates the disc surface, the depth of the cut (impression) being controlled by extent of tool closure. The dimensions of the tool are such that total closure results in complete penetration of the disc by the knife edge. The disc may be marked in quadrant or octant sectors by rotating one face of the tool relative to the other between successive marking operations. The appearance of a quadrant-marked disc and the typical rupture pattern for such discs are illustrated in Figure 3.

During a preliminary investigation of disc-marking techniques, it was observed that quadrant-marked discs ruptured more uniformly than octant-marked discs, hence, all subsequent work used the quadrant sectors. It was also found that poor reproducibility was obtained when the depth of the radial marks was controlled by applying a partial load to the marking tool with a torque wrench. Therefore, the thickness of uncut metal under the marks was controlled by

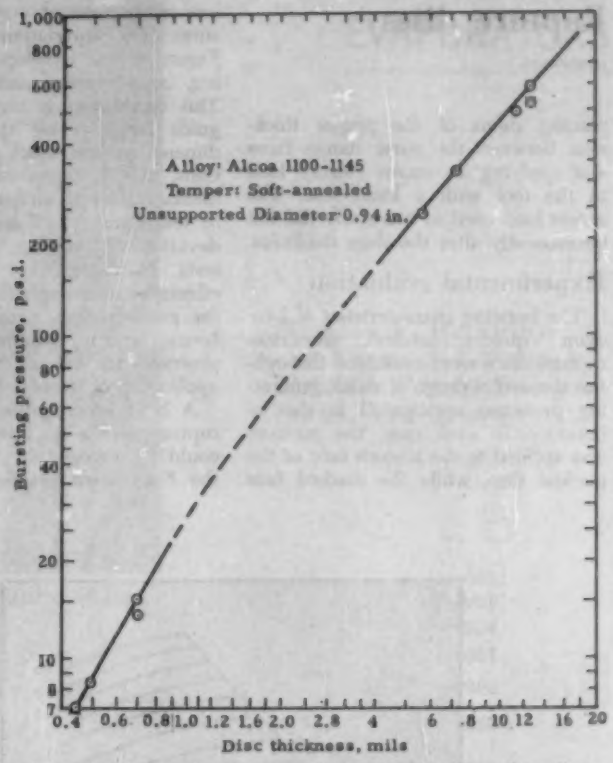

Figure 1. Rupture pressure correlation for smooth-surface discs.

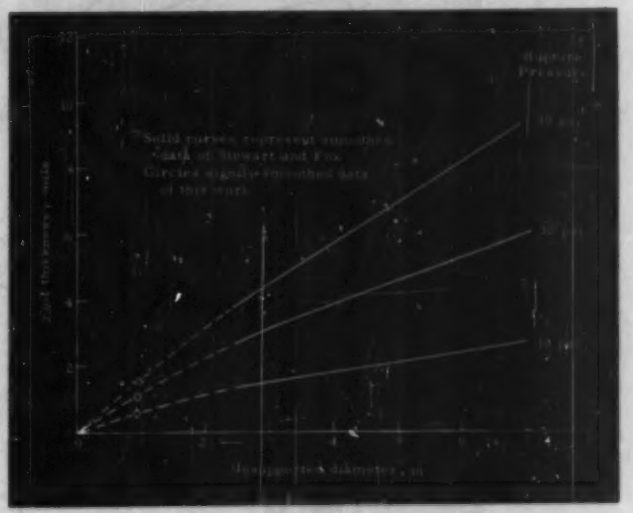

Figure 2. Comparison of experimental bursting pressure correlation with literature data for soft aluminum smooth-surface rupture discs.

Rupture discs

continued

placing shims of the proper thickness between the outer flange faces and applying an excess closure load to the tool with a hand vise. The excess load used in this study did not permanently alter the shim thickness.

Experimental evaluation

The bursting characteristics of 1-in. diam., quadrant-marked, aluminum rupture discs were evaluated throughout the useful range of shock-generating pressures anticipated in the laboratory. In each case, the pressure was applied to the smooth face of the marked disc, while the marked face was maintained at atmospheric pressure. The correlation presented in Figure 4 was developed by smoothing, cross-plotting, and interpolating. This correlation is used solely as a guide for selecting appropriate disc dimensions for shock tube applications, and it reproduces the experimental data with an average deviation of less than ± 4% and a maximum deviation of less than ± 15%. Several tests indicated that age-annealing effects became negligible by the time the marked discs were used (several hours), and no definite evidence was observed for creep effects following application of stress to the discs.

A brief investigation revealed that rupture of the imprinted-sector discs could be successfully triggered after the discs were prestressed to about 90% of the predicted rupture pressure. Sharp-point needles, 1/32 in. diam., were found to perform satisfactorily, provided that the needle point pierced the center of the disc or the indentation of one of the radial marks. It was also observed that blunt needles with a sharp edged tip, round-point needles, and needles tipped with ¼-in. spheres were not generally satisfactory for this purpose.

Examination of Figure 4 reveals that the natural rupture pressure decreases with increasing disc thickness for a constant uncut thickness. This effect probably results from the increasing relative stiffness caused by the increasing disc thickness-to-diameter ratio. Greater relative stiffness increases the concentration of stresses on the radial marks, and hence, it should reduce the bursting strength of the discs.

The ratio of the residual uncut thickness-to-original disc thickness was found to be a critical variable for influencing the type of rupture achieved, either for natural or triggered rupture. If the marks are too shallow, the rupture pattern is not controlled by the imprinted pattern. If the marks are too deep, the bursting pressure stresses may be insufficient to cause complete opening of the quadrant sectors. However, uniform and complete opening of the discs, such as is illustrated in Figure 3, is best achieved when the ratio of the uncut-to-original thickness is between about 0.5 and 0.6. This optimum thickness ratio is especially critical when triggered rupture is to be achieved by puncture of the stressed disc.

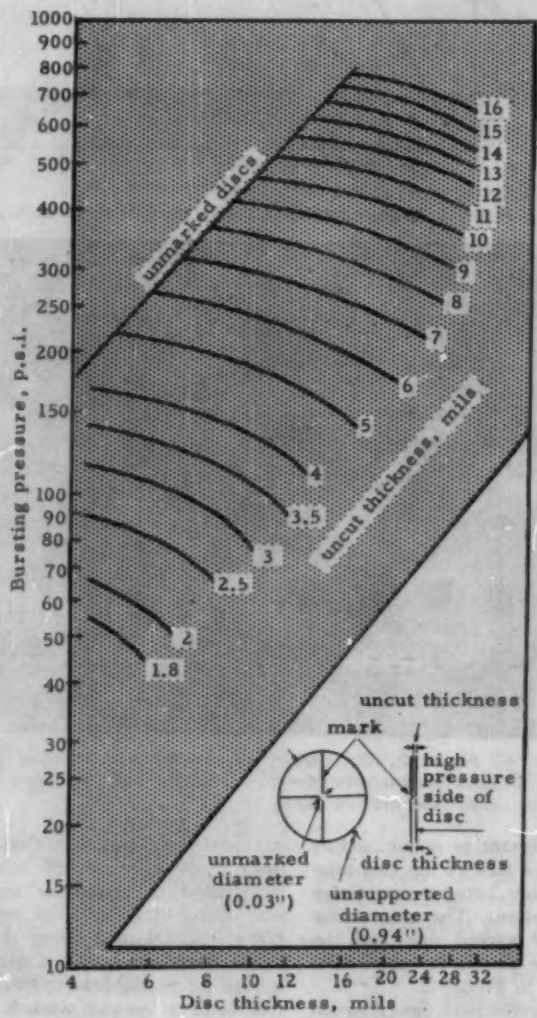

Figure 4. Pressure correlation for imprinted-sector, soft aluminum, rupture discs.

Conclusions

The results of this investigation demonstrated that quadrant-marked, imprinted-sector rupture discs yield a reproducible, clean-cut bursting pattern. This type of rupture is more suitable for shock tube applications than the irregular fracture pattern observed for smooth-surface rupture discs. The bursting strength of imprinted-sector discs is as reproducible as that of successfully ruptured smooth-surface discs.

ACKNOWLEDGMENT

This work was sponsored by the Gulf Research & Development Company as a part of the research program of the Multiple Fellowship on Petroleum.

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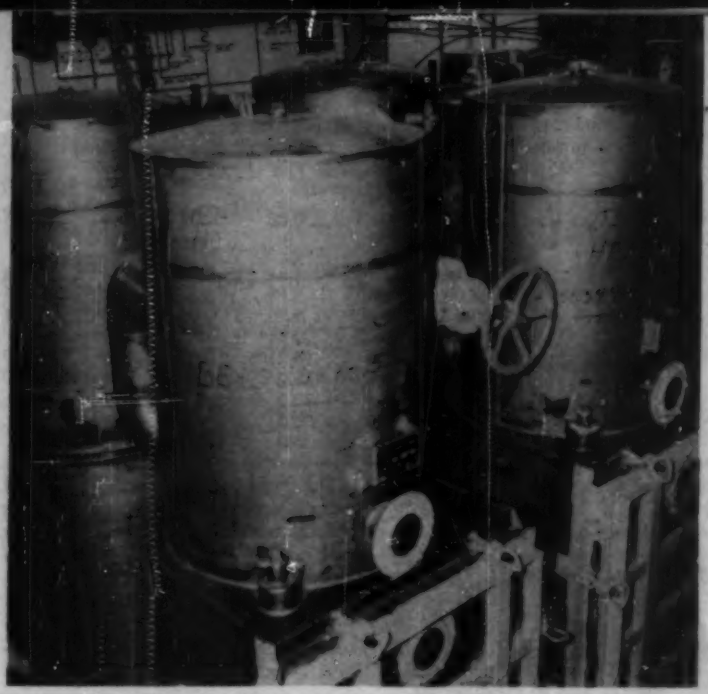

Four-stage multiple-effect evaporator used for demineralization of sea water. (Photo courtesy Maxim Corp.)

HERMAN F. REINHOLD
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Hercules Powder Company
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Multiple-effect evaporation

... *how to get the optimum number of effects*

IT IS AXIOMATIC that chemical process plants should be designed so that no money is spent on optional equipment which will not show at least as high a return rate as management expects on the over-all plant project. Often economic calculations to insure this goal are not undertaken because of the impression that they will take an inordinate amount of additional time and effort. Actually, in many cases this is not so—optimum design for a number of unit operations can be reduced to a fairly straightforward routine procedure. In the following paper such a procedure is developed for the design of multiple-effect evaporators. By reducing the results to a simple form the authors show how to rapidly arrive at the proper number of stages to employ. Use of procedures like this will often result in substantial savings in equipment cost.—JOHN HAPPEL

THE CHOICE OF the number of effects for a given multiple-effect evaporation job involves considerable work in balancing fixed costs and operating costs to arrive at the optimum. The usual procedure for arriving at a final design is to calculate in detail the total costs when the number of effects is varied, and then select as the optimum the number of effects giving the lowest total costs. Short of the final design, however, approximate results may be obtained without resorting to this tedious procedure. This can be done by making the relatively simple calculations for a single effect and applying the method described below to arrive at the optimum number. When the final design is to be prepared, this number will serve as a convenient starting point, so that the number of detailed calculations may be minimized.

Fixed cost

According to Coston and Lindsey (*3*), the annual fixed cost of a multiple-effect evaporator is approximately proportional to the 0.75 power of the number of effects.

$$V_1 = \frac{C_1}{A} N^{0.75} \qquad (1)$$

The estimated cost of a single effect (C_1) can be obtained from a number of sources (*1, 7*) once the heat transfer surface requirements are known.

Operating costs

Operating costs can be divided into steam cost and all other operating costs (labor, cooling water, power and maintenance) such that

$$V_2 = \frac{kWC_2}{S} + V_0 \qquad (2)$$

The principal operating cost is for the steam consumed. This is a function of the number of effects and the quantity of liquid evaporated per

Multiple-effect

continued

pound of vapor fed to each effect. For aqueous solutions, in a single effect, the steam economy (S) ranges from 0.80 to 0.92 (*2*) depending on feed temperature, operating pressure, and other factors, such as heat of solution and effectiveness of insulation. As additional effects are added, each can be expected to produce 0.85 to 0.92 pounds of liquid vaporized per pound of vapor feed. Examples of steam economy for industrial evaporators are given in the literature (*2, 3, 4, 6*).

Steam economy can be expressed as:

$$S = s_1 + s_1 s_2 + s_1 s_2^2 + \cdots + s_1 s_2^{N-1} \quad (3)$$

Since S is a geometric series, it can also be expressed as:

Table 1. Maximum value of cost factor (P) vs. optimum number of effects at various values of steam utilization

		Cost Factor $(P) = AhWC_2/C_1$					
	s_1=	0.80		0.85		0.92	
Optimum No. of Effects (N)	s_2=	0.92	0.85	0.92	0.85	0.92	0.85
1		1.14	1.19	1.21	1.26	1.31	1.36
2		3.00	3.15	3.19	3.35	3.45	3.62
3		5.53	5.86	5.88	6.23	6.36	6.74
4		8.69	9.33	9.24	9.92	10.0	10.7
5		12.5	13.6	13.2	14.4	14.3	15.6
6		16.9	18.8	18.0	19.9	19.4	21.6
7		21.9	24.8	23.3	26.4	25.2	28.6
8		27.5	32.0	29.2	34.0	31.6	36.8
9		33.8	40.5	35.9	43.0	38.8	46.6

$$S = \frac{s_1(1 - s_2^N)}{(1 - s_2)} \quad (4)$$

and Equation (2) becomes

$$V_2 = \frac{(1 - s_2)\, hWC_2}{s_1(1 - s_2^N)} + V_0 \quad (5)$$

The term V_0 includes the cost of operating labor, cooling water, power and maintenance. Operating labor does not change with the number of effects. Maintenance costs vary directly with the number of effects (*5*) in the range of \$500 to \$600/yr. for units of 1000 sq. ft. of heating surface. Cooling water cost varies in-

Illustrative problem

It is desired to concentrate an aqueous solution of NaOH from 4.0 wt.-% to 33 wt.-% in a long tube vertical evaporator. The feed rate is 22,500 lb./hr. The evaporator is to be of steel construction.

Other data are as follows:

Available steam temperature = 240°F (24.97 psia.)
Saturation temperature of evaporating water = 120°F (26.5 in. Hg vac.)
Over-all heat transfer coefficient

$$(U_o) = 100 \frac{\text{Btu.}}{(\text{hr.})\,(\text{ft.}^2)\,(^\circ\text{F})}$$

Annual operation (h) = 8200 hr.
Steam cost (C_2) = \$0.55/1000 lb.
Required payout time (A) = 2.0 yr.
Feed enters at 120°F
What is the optimum number of effects and the cost of the installation?

Solution:

Assume a single-effect evaporator
Water evaporated

$$= 22{,}500 \times 0.04 \left(\frac{0.96}{0.04} - \frac{0.67}{0.33}\right) = 19{,}780 \text{ lb./hr.}$$

Boiling point rise of 33% NaOH solution = 34°F
Evaporation temperature = (120 + 34) = 154°F
Δt = (240 − 154) = 86°F

Heat Balance* Btu./hr.

Heat out:	Water vapor at 154°F = $19{,}780 \times 1{,}128$	= 22,300,000
	33% NaOH sol. at 154°F = 2720×115 =	313,000
	Total	= 22,613,000
Heat in:	4% NaOH sol. at 120°F = $22{,}500 \times 85$ =	1,912,000
	Heat transferred (q)	= 20,702,000
	Total	= 22,614,000

$$\text{Heat transfer surface} = \frac{20{,}702{,}000}{100 \times 86} = 2410 \text{ sq. ft.}$$

From Aries and Newton (*1*) Fig. 19, page 39, the cost of a single effect (C_1) = \$26,000
Optimum number of effects:

$$(P) = \frac{AhWC_2}{C_1} = \frac{2.0 \times 8200 \times 19{,}780 \times 0.00055}{26{,}000} = 6.86$$

From Table 2, the optimum number of effects (N) is four.

The cost of the multiple-effect installation is

$$26{,}000 \times (4)^{0.75} = \$73{,}500$$

The steam economy will be in the range 2.6 to 3.2 lb. evaporated/lb. steam.

(If copper construction is used, the cost of a single effect would be \$71,000, in which case

$$(P) = 6.86 \times \frac{26{,}000}{71{,}000} = 2.52$$

and the optimum number of effects is two. The cost of the installation is \$120,000.)

It may be of interest to note the effect of boiling point rise on the over-all temperature difference. This is shown in Table 3. For four effects, the available Δt = (240−120−47) = 73°F, compared to 86°F for the single effect.

For the sake of comparison, the investment costs and steam costs for three, four, and five effects are shown in Table 4, based on the estimated cost of \$26,000 for one effect and several representative combinations of steam utilization. In Table 5 the steam savings for one and two years and the actual payout are compared to the increase in the installed cost of the unit when considering increases from three to four, and four to five effects. In each case it is clear that for a two-year payout, the use of four effects is justified and the use of five effects is not.

* Basis: Enthalpy of liquid water at 32°F = 0.

versely as the number of effects, and is of the same order of magnitude as the maintenance costs. Power costs increase somewhat with additional effects because of increased pumping requirements.

The variations of the above costs with the number of effects tend to offset each other and the magnitude of the collective costs is small with respect to steam cost. Thus, for practical purposes, the factor V_0 can be considered constant.

Total annual cost and optimum conditions

The total annual cost (V) is the sum of the annual fixed and operating costs:

$$V = V_1 + V_2 = \frac{C_1}{A} N^{0.75} + \frac{(1 - s_2)\, hWC_2}{s_1(1 - s_2^N)} + V_0 \qquad (6)$$

By definition, the total annual cost will be a minimum when the optimum number of effects is selected. If N were a continuous variable, this condition would be met when $\frac{dV}{dN} = 0$. Since there cannot actually be a fractional part of an effect, N can only be a positive whole number. In this case, the calculus of finite differences is applicable, and the total annual cost will be a minimum when $\Delta V = 0$. Using the calculus of finite differences to differentiate Equation (6) and setting ΔV equal to 0, we obtain:

$$\Delta V = \frac{C_1}{A}\left[(N+1)^{0.75} - N^{0.75}\right] - \frac{hWC_2(1-s_2)^2\, s_2^N}{s_1(1-s_2^N)\,(1-s_2^{N+1})} = 0 \qquad (7)$$

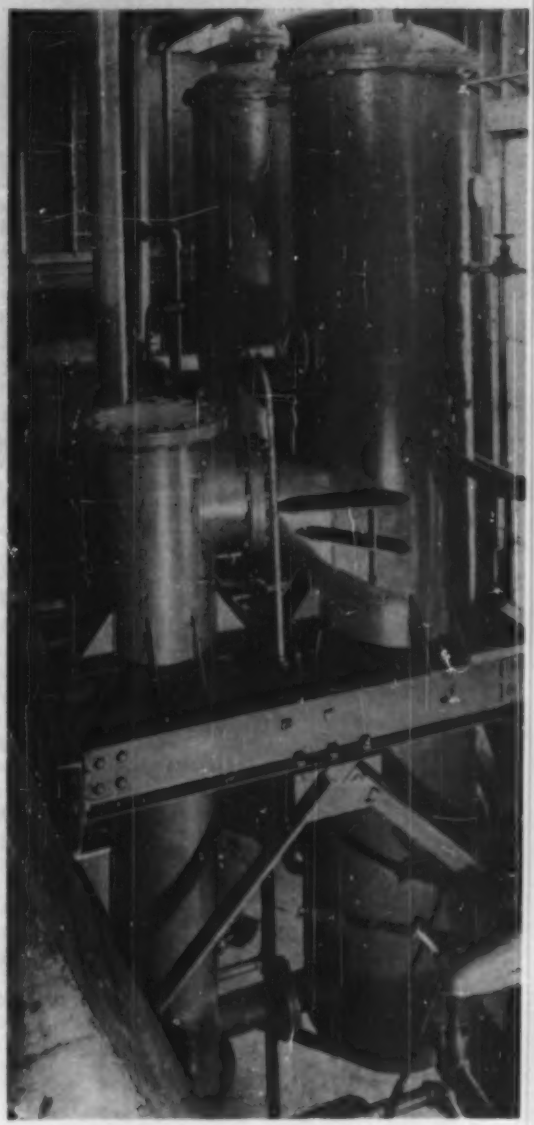
The variables can be separated to give Equation 8, below.

The group on the left side of Equation (8) is the cost factor (P), which, along with s_1 and s_2 characterizes the evaporation operation. The form of Equation (8) still does not lend itself readily to the calculation of N from the other data, so we have solved Equation (8) for the cost factor (P) corresponding to integral values of N at various values of s_1 and s_2. The results are shown in Table 1.

$$\frac{AhWC_2}{C_1} = \frac{[(N+1)^{0.75} - N^{0.75}]\, s_1\,(1 - s_2^N)\,(1 - s_2^{N+1})}{(1 - s_2)^2\, s_2^N} \qquad (8)$$

Table 2. Cost factor (P) vs. optimum number of effects—simplified form

Optimum No. of Effects (N)	Cost Factor (P) $= AhWC_2/C_1$
1	up to 1.3
2	1.4 to 3.3
3	3.4 to 6.2
4	6.3 to 9.9
5	10.0 to 14.4
6	14.5 to 19.9
7	20.0 to 26.4



Double-effect evaporator for recovery of zinc plating solution from rinse water. (Buflovak Div, Blaw-Knox)

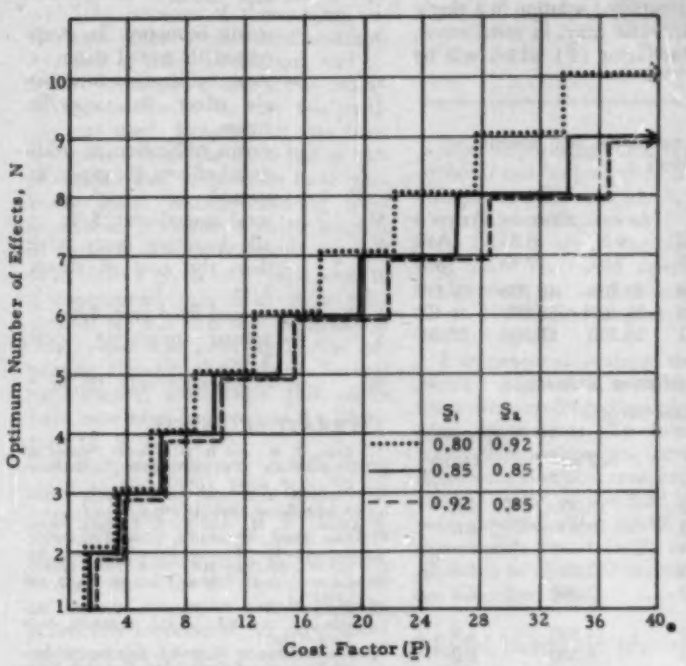


Figure 1. Variation of optimum number of effects with cost factor.

Multiple-effect

continued

To find the optimum number of effects:

1. Calculate the cost factor (P) from process and economic data.
2. Estimate s_1 and s_2.
3. Compare the calculated value of (P) with the values given in the appropriate column of Table 1. The optimum number of effects will be the value of N corresponding to the lowest value of (P) in the table that is higher than the value of (P) calculated in Step 1, above.

Figure 1 shows the stepwise variation of N with (P) for a few combinations of s_1 and s_2. It can be seen that the range of values of (P) for a given N does not differ much for different values of s_1 and s_2 as long as N is small, but beyond four effects, the values of s_1 and s_2 become significant. Without more detailed information, however, values of $s_1 = s_2 = 0.85$ are a fair estimate of what may be encountered in practice. Table 2 is a simplified version of Table 1, prepared on this basis, to be used when s_1 and s_2 are unknown.

It will be noted that the tables apply only to aqueous solutions. For nonaqueous solutions, Equation (8) can be used, with appropriate values of s_1 and s_2, to construct similar tables.

In selecting the optimum number of effects, it is assumed that all effects have equal heat transfer surface. This surface, since it is obtained essentially for a single-effect evaporator, is estimated by using a heat transfer coefficient based on the physical properties of the concentrated solution.

With additional effects, the boiling solution becomes progressively more dilute, promoting higher heat transfer coefficients. However, there will be an opposing tendency toward lower boiling coefficients due to the lower temperature difference per effect. Also, the total available temperature difference will be somewhat lower because the total boiling point rise is not taken into account in calculating on the basis of a single effect. A discussion of the many variables influencing heat transfer coefficients may be found in a number of references such as Kern (*4*).

The use of a heat transfer coefficient based on the physical properties of the concentrated solution in a single effect evaporator may, in some cases, yield a cost factor (P) which will be somewhat low. The experienced designer, however, may prefer to assume an average coefficient in calculating the heat transfer surface requirements of the single effect.

Table 3. Effect of boiling point rise on overall Δt of illustrative problem

Effect**	lb. H_2O	NaOH lb. NaOH	NaOH Conc. Wt.-%	B.P.R., °F
1		2.03	33.0	34
2		7.53	11.7	7
3		13.02	7.2	4
4		18.51	5.1	2
				—
			Total B.P.R. =	47

**Either forward or backward feed will result in the same total B.P.R.

Summary

A cost factor has been developed relating the optimum number of evaporator effects to process requirements, materials of construction, and economic consideration. The cost factor is easily computed and the corresponding number of effects obtained from Tables 1 and 2.

The number of effects so determined can be used for making preliminary cost estimates or as a starting point for a detailed final estimate.

ACKNOWLEDGMENT

We would like to acknowledge the suggestion of Professor John Happel that the calculus of finite differences be applied.

NOTATION

A = pay-out time—years (the time elapsed before the invested capital is completely recovered by net earnings before taxes, depreciation, and a return on the investment).

C_1 = cost of a single effect including auxiliaries, $

C_2 = cost of steam, $/lb.

h = operating time, hr./yr.

N = number of effects

(P) = cost factor = $\dfrac{AhWC_2}{C_1}$

S = steam economy, lb. evaporated/lb. initial steam

s_1 = steam utilization in a single effect, lb. vapor/lb. steam

s_2 = steam utilization in additional effects, lb. vapor/lb. steam

V = total annual cost, $/yr.

V_0 = all operating costs other than the cost of steam, $/yr.

V_1 = annual fixed cost, $/yr.

V_2 = annual operating cost, $/yr.

W = evaporation rate, lb./hr.

Table 4. Comparison of evaporator cost, economy, and steam costs for illustrative problem

No. of Effects	Evap. Cost $		Economy lb. Evap./lb. Steam			Annual Cost of Steam $		
		s_1 =	0.80	0.85	0.92	0.80	0.85	0.92
		s_2 =	0.92	0.85	0.85	0.92	0.85	0.85
3	59,300		2.21	2.19	2.36	40,400	40,700	37,800
4	73,500		2.84	2.71	2.93	31,400	32,900	30,400
5	86,800		3.41	3.15	3.41	26,200	28,300	26,200

Table 5. Comparison of payout for illustrative problem

Change in No. of Effects	Increase in Evap. Cost $	Steam Savings $/2 yr.***	Payout — Years
for $s_1 = 0.80$ and $s_2 = 0.92$			
3 to 4	14,200	9,000	18,000	1.6
4 to 5	13,300	5,200	10,400	2.6
for $s_1 = 0.85$ and $s_2 = 0.85$			
3 to 4	14,200	7,800	15,600	1.8
4 to 5	13,300	4,600	9,200	2.9
for $s_1 = 0.92$ and $s_2 = 0.85$			
3 to 4	14,200	7,400	14,800	1.9
4 to 5	13,300	4,200	8,200	3.2

*** *Corresponding to a payout of 2 years.*

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Fluidized-bed reactor studies

Tracers used to evaluate gas-solids contacting—mathematical model developed for use in experiments and applications to chemical reaction results

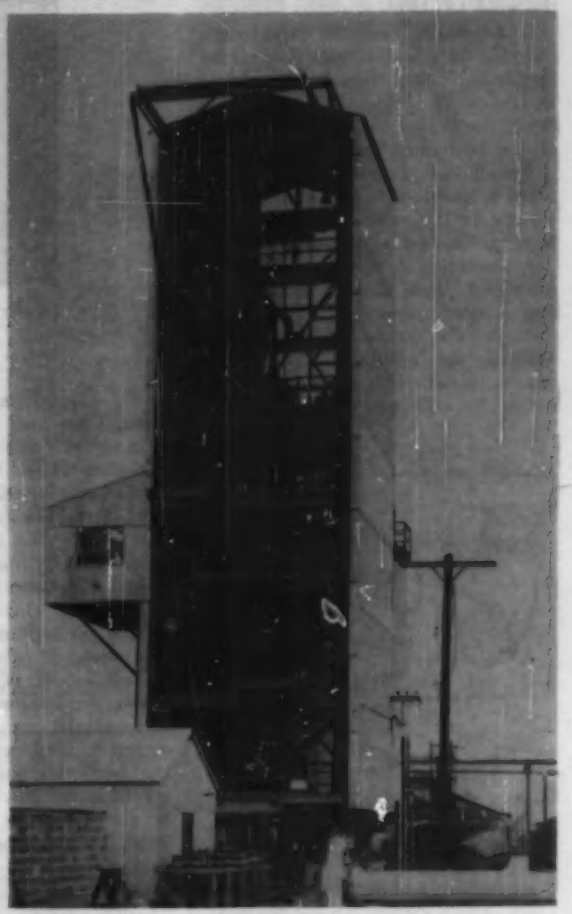

Figure 1. Very large equipment was built to study scale-up problems.

FLUID BED REACTORS have gained wide use because of three main advantages: their temperature uniformity, ease of solids circulation, and effective utilization of the active catalytic surface due to the very fine particle size used. However, it has been recognized from the early use of this technique that large units have generally given results differing from small-scale lab units. A larger amount of catalyst is almost always required to achieve a given conversion level in a commercial unit than in a pilot unit. It is clear that this difference is due to the flow behavior of the gas passing through the reactor. Several experimental studies on this effect have now been reported in the literature (*6, 9, 15, 16*).

Scaling up reaction results from small to large size fluid beds is an important and difficult problem. The flow behavior in large units differs from that in small units substantially. In some cases the difference has been so large as to render the large units practically inoperable. An experimental approach to this problem is presented in this paper.

The importance attached to the problem can be judged from the pilot equipment built to study it, Figure 1. Very large units, up to 5 ft. diam., were built to study the effect of the unit size. The units operated with compressed air as fluidizing gas, at 80 to 100°F, and at pressures up to 100 lb./sq. in.

For practical reasons the experiments conducted in such large equipment were restricted mainly to tracer type experiments. To interpret the tracer information in terms of the effect on a chemical reaction, a mathematical model of the fluid bed action was required. The model used, the experiments based on it, and its application to chemical reaction results, are described herein.

Model based on observation

The general nature of the gas flow in fluid beds has been described many times, Figure 2. Part of the gas rises rapidly in pockets or "bubbles" containing very little solids. In addition, there is obviously very rapid mixing of the surrounding solids. Two inferences are clear: the bubble flow presents a mechanism for the gas to get through the bed and yet contact only a small percentage of the solids present; in addition, top-to-bottom mixing is vigorous, and depending on the kinetics of the reaction, might be harmful.

Two qualitative observations can be made regarding the magnitude of these factors:

1. All the gas comes in contact with some solids; none of it bypasses completely. This is shown by experiments on mass transfer between gas and solids in fluid beds. They have had to be carried out in very thin beds,

of the order of 1 in., to get something to measure. With deeper beds the exit gas leaves in equilibrium with the solid (*3*, *13*).

2. Chemical reaction experiments have shown efficiencies varying all the way from "better than fixed beds" to as low as 5% of fixed beds. The low figure shows that the bypassing action of the bed must be important (*9*).

The fluid-bed model used in this work is based on these observations, Figure 3. The bulk of the gas rises through the bed as bubbles, and this gas is assumed to flow through in piston flow; that is, there is no backmixing. A small amount of the gas rises through the surrounding gas-solids mixture (the "emulsion") and is vigorously mixed. This mixing is characterized by a diffusion coefficient.

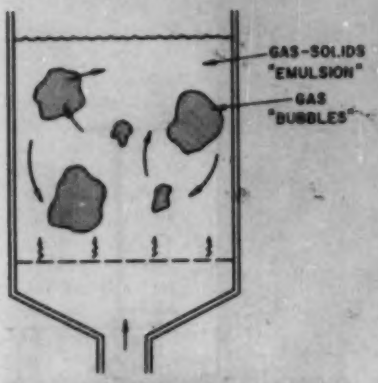

Figure 2. Gas by-passing (as "bubbles"), and back-mixing, are characteristic of fluid beds.

Fortunately, exchange of gas occurs between the bubbles and the surrounding emulsion. This occurs in at least two ways: flow due to the pressure difference between the bottom and top of the bubble; and break-up and reforming of bubbles. This exchange is called "crossflow". It is generally expressed as a ratio, dividing by the gas flow as bubbles. A crossflow ratio of three, for example,

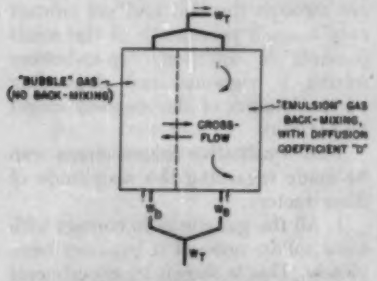

Figure 3. Model of fluid bed contacting has two important parameters: crossflow and back-mixing.

Figure 4. Fluidization of fresh cracking catalyst with air at 1 atm.

would mean that a bubble rising through the bed would exchange its volume with the surrounding emulsion three times.

Chemical reaction in the bed is assumed to occur entirely in the emulsion phase; the main interest is in heterogeneous reactions, and it is assumed that there is no catalyst inside the bubbles. This may or may not be a good assumption, depending on the magnitude of other factors involved.

This model is not perfect. Close examination shows several important assumptions: *e.g.*, the crossflow is assumed to occur uniformly throughout the bed; the gas flow through the emulsion and the gas volume held up in the emulsion are assumed constant, independent of total flow rate.

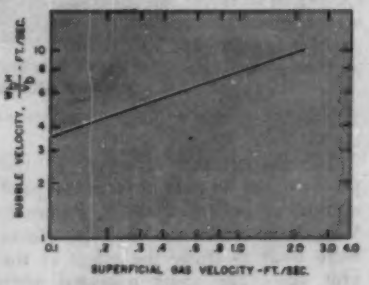

Figure 5. Bubble velocity in fresh cracking catalyst.

However, the model is as complex as can be justified with present knowledge, and it does give quantitative significance to the more important flow effects.

Three sets of experiments were carried out to describe the model: experiments to measure gas flow rates and volumes in the bubbles and emulsion; mixing experiments to measure the diffusion coefficient; and mass transfer experiments to measure the crossflow.

Simple fluidization experiment—some bed parameters

The gas flow rates through the bubbles and through the emulsion, and the volume occupied by bubbles and emulsion gas in the bed, were estimated from simple fluidization experiments. Figure 4 shows data obtained by aerating fresh cracking catalyst in a 4-in. diam. column. The ordinate is the reciprocal of the pressure gradient in the fluidized column and thus has units of cu. ft. of bed (catalyst plus air)/lb. of catalyst. The bed was fluid at an aeration rate of 0.01 cu.ft./min. air. When the air rate was increased to about 0.034 cu.ft/min., small disturbances appeared, indicating that bubbles were forming. This air rate was assumed to be the maximum amount of gas which flows through the emulsion. The gas velocity through the emulsion ($W_e H/V_e$) was assumed constant with further increase in gas velocity. At the bubble point there was usually an unstable condition, the bed first expanded, then collapsed, with further addition of air. With increased air past the bubble point, the amount of gas rising in bubbles was assumed to be the total amount

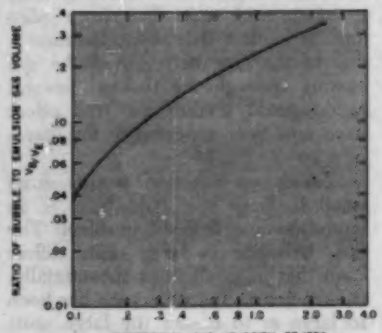

Figure 6. Gas hold-up in a fluid bed of fresh cracking catalyst.

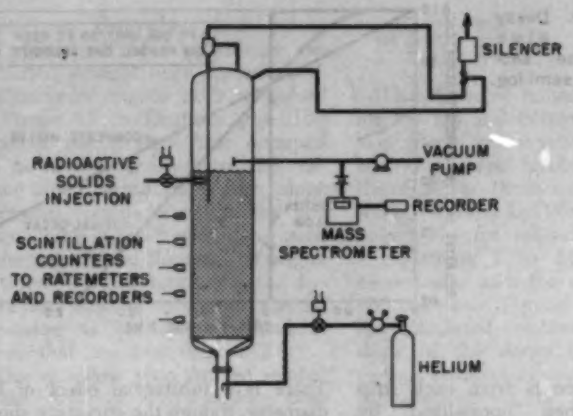

Figure 7. Arrangement for gas and solid tracer tests.

of gas fed, W_t, minus the amount of gas seeping through the emulsion, W_e.

The volume of the bed is composed of three parts: the volume of the solid, the volume of gas in the emulsion (V_e), and the volume of the gas bubbles (V_b). At the bubble point V_b, is zero. From the total volume at the bubble point and the density of the solid, the emulsion gas volume, V_e, was calculated. With further increase in aeration rate, this was assumed to remain constant. The volume of gas bubbles, V_b, was then the extra volume of the bed over the volume at the bubble point. The volumes and flow rates are illustrated in Figure 4.

Catalyst normally used in fluid beds has a size range of about 20 to 150 microns. The emulsion gas velocities for such fine material are extremely small. As a result, an exact value of the emulsion velocity is not critical for this work. (Table 1.)

The bubble gas travels much faster than the emulsion gas, and its velocity varies with the superficial gas rate, Figure 5. Figure 6 shows the ratio of

Table 1. Emulsion gas velocities of fresh cracking catalyst

Catalyst Size Range, Microns	Emulsion Gas Vel. (W_eH/V_e), ft./sec.
20-40	0.0042
40-60	0.0053
60-80	0.012
normal fresh cat.	0.016
80-100	0.041
100-150	0.054

bubble to emulsion gas volumes. In the range of gas velocities covered in this work, the volume of the bed occupied by the bubbles is a fairly small fraction of the total gas volume in the bed.

Diffusion theory

The emulsion mixing coefficient, D, was determined in large scale tests by means of radioactive solids tracers, Figure 7. Tagged solids were injected near the top of the fluidized bed and the appearance of radioactivity at various locations below the injection point was monitored. In analyzing these data it was assumed: (1) that the tagged solids were injected uniformly in a plane over the top of the fluid bed and traveled down through the bed by diffusion; (2) the diffusion coefficient over the entire cross-section of the bed was constant; and (3) there was no loss of fluidized solids at either boundary 1, 2, 3, 4, 5, 6.

The differential equation and boundary conditions which describe this situation are:

$$D\frac{\partial^2 C}{\partial X^2} = \frac{\partial C}{\partial t} \quad (1)$$

Boundary conditions:

$$\text{at } t=0,\ C=C_0 \text{ for } 0 \leqslant X \leqslant X_1 \quad (2)$$

$$C=0 \text{ for } X_1 < X \leqslant L \quad (3)$$

(where X_1 represents the layer of radioactive catalyst injected at the top of the bed.)

$$\text{at } t=\infty, \qquad C=C_\infty=\frac{C_0 X_1}{L} \quad (4)$$

$$\text{for } t \geqslant 0,\ \frac{\partial C}{\partial X}=0 \text{ at } \begin{matrix} X=0 \\ X=L \end{matrix} \quad (5)$$

For the case where the tagged solids represent only a small fraction of the total solids in the bed (i.e., X_1 is very small), the solution of Equation (1) is:

$$\frac{C}{C_\infty}=1+2\sum_{n=1}^{\infty} e^{-(n\pi)^2\frac{Dt}{L^2}}\cos\frac{n\pi X}{L} \quad (6)$$

This equation gives the approach to final equilibrium, C/C_∞, as a function of two dimensionless parameters: A time parameter, Dt/L^2, and a position parameter, X/L. By matching measured tracer data with calculations, it is possible to calculate the diffusion coefficient.

Mixing tests. The radioactive tracer used was Iodine-132. Radioactive tellurium was obtained from the Brookhaven National Laboratory in an Iodine-132 generator and the radio-

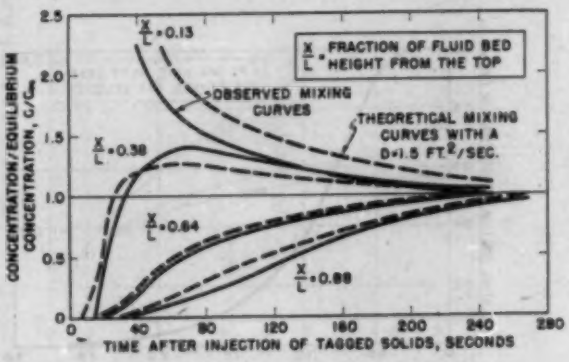

Figure 8. Solids mixing rate data: 15-in. diam. bed, 30 ft. deep, 0.8 ft./sec. superficial gas velocity.

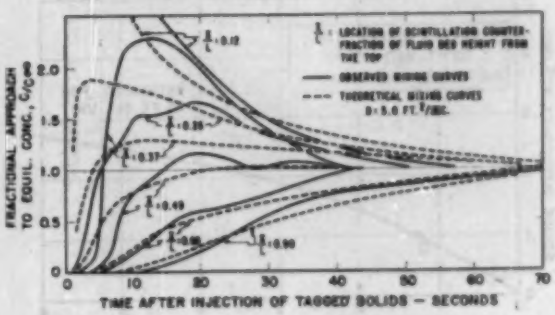
FRACTIONAL APPROACH TO EQUIL. CONC., C/C∞
TIME AFTER INJECTION OF TAGGED SOLIDS — SECONDS
X/L = LOCATION OF SCINTILLATION COUNTER-FRACTION OF FLUID BED HEIGHT FROM THE TOP
OBSERVED MIXING CURVES
THEORETICAL MIXING CURVES D=5.0 FT.²/SEC.

Figure 9. Solids mixing rate data: 5-ft. diam. bed, 32 ft. deep, 0.8 ft./sec. superficial gas velocity.

active iodine was obtained by a "milking" technique. This was found to be a very convenient combination. The iodine has a half-life of 2.4 hr. so there was little decay in activity during the course of the experiment. At the same time the activity in the unit died away rapidly enough that one test per day could be carried out without having high residual background counts left over from previous tests. The radioactive tellurium has a half-life of 77 hr. so that one charge would last for a week's operation, and could be milked every day.

The iodine was recovered as NaI and was impregnated on about 50 g. of the fluid catalyst. The amount of radiation used varied from 50 to 100 mc. The impregnated catalyst was supported at the desired position in the unit (usually just above the bed) in a special cartridge, and was discharged into the bed by air pressure which ruptured a diaphragm at the end of this cartridge. The tracer movement down the unit was monitored by scintillation counters at several levels at the side of the unit. In addition, catalyst from the middle of the bed was generally sampled at one point, and this catalyst was also monitored by a scintillation counter. The scintillation counters had fan-shaped collimators so that they "saw" a thin layer across the bed. This system gives most weight to the radioactivity closest to the wall; essentially all the activity measured came from within 18 in. of the wall. Each scintillation counter was connected to a rate meter and the rate meter connected in turn to automatic recorders. The time of injection of the radioacitve solid, zero time, was automatically marked on all the recorders.

The data were interpreted by comparison with Equation 6. The final equilibrium concentration, C_∞, was obtained by letting the recorders run long enough so that the radioactivity level had become constant (5 to 10 min.). The records from each strip chart were then "normalized" by dividing the measured activity by the final equilibrium activity, as read from each chart. This gave values of C/C_∞ as a function of time for various known values of X/L, the location of each scintillation counter. By a trial-and-error procedure (trying out various diffusion coefficients) the best fit for all of the measured curves with their corresponding theoretical curves was determined.

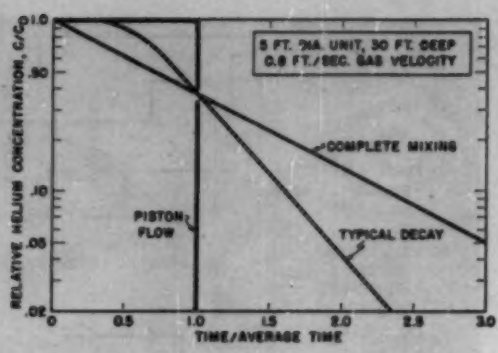

Figure 12. Decay curves give straight-line sections on semi-log plots.

Mixing data. Typical results obtained in the radioactive mixing tests are shown in Figures 8 and 9. The assumption of a diffusional mechanism for the mixing in the 15-in. diam. unit fits the data reasonably well. The gross circulation patterns within the bed are apparently small in comparison with the bed depth tested, 30 ft. Data from the larger units are much more erratic; there is evidence of a gross circulation pattern with smaller scale mixing superimposed on it. It appears that a single mixing parameter is inadequate. A statistical treatment of the data is called for, but has not been done. Instead a "best" value of the diffusion coefficient was determined which will result in practically complete mixing of the bed in the observed time.

Results from a large number of tests are summarized in Figure 10. There is a substantial effect of bed diameter, though the curvature shown is opposite to that reported by Askins *et al* (*2*). The rate of mixing shown for the 5-ft. unit is enormous; it means that 50 g. of catalyst is essentially completely mixed in 15 tons of catalyst in less than one minute. This, of course, is the reason for the well-known isothermal nature of large fluid beds.

Crossflow ratio from time-of-contact experiment

The crossflow, W_s, was determined by the so-called time-of-contact experiment. A small amount of tracer gas, helium, was added to the fluidizing air and the unit run till equilibrium was established. The tracer was then abruptly cut off by a solenoid valve, Figure 7, and its concentration in the exit gas was monitored as it gradually decayed away. This was done by a mass spectrometer*, with the ionizing current recorded on a strip chart. A typical experimental curve is shown in Figure 11. This experiment gives directly the residence time distribution of the gas flowing through the bed, and has been used by many experimenters, (*5, 6, 7, 10*). Mason and Gilliland

* Consolidated Engineering Leak Detector.

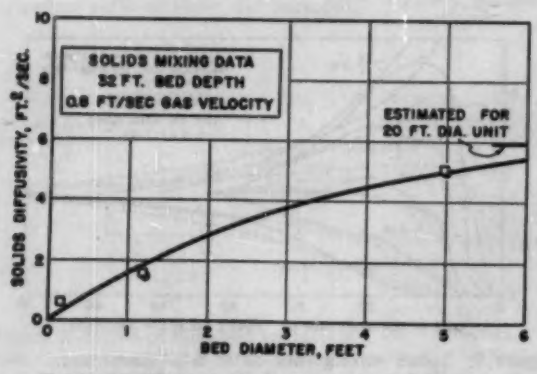

Figure 10. Mixing is faster in large units.

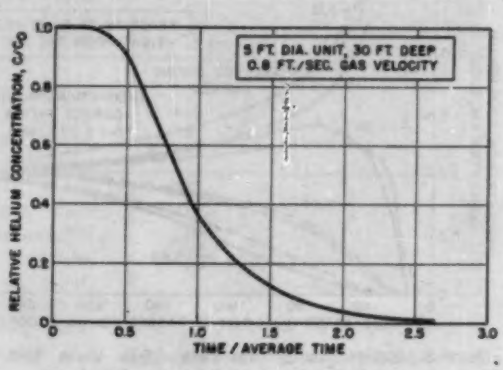

Figure 11. Typical decay curve.

pointed out that when these curves are plotted on semi-logarithmic coordinates, straight lines are obtained. The curve of Figure 11 is re-plotted in Figure 12 to illustrate this. The slope of the straight line obtained can be used to characterize the residence time distribution. A steep slope represents conditions within the bed approaching piston flow—that is, good contacting. A line through the origin, of slope —1/2.3, represents the hypothetical case of complete mixing. Bypassing as bubbles can lead to slopes that are less than 1/2.3.

The crossflow ratio can be related to the slope of the residence time distribution by a mathematical analysis, based on the model of Figure 3, 7, 8, 9, 10, 11, 12, 13.

Material balances on the bubble and emulsion phases lead to the following equations:

$$V_b\frac{\partial C_b}{\partial t}+W_b\frac{\partial C_b}{\partial Z}=W_e(C_e-C_b) \quad (7)$$

$$V_e\frac{\partial C_e}{\partial t}-\frac{DV_e}{L^2}\frac{\partial^2 C_e}{\partial Z^2}+W_e\frac{\partial C_e}{\partial Z} = W_e(C_b-C_e) \quad (8)$$

The exit tracer composition is given by:

$$(W_b+W_e)C_3=W_bC_{b2}+W_eC_{e2} \quad (9)$$

The boundary conditions used are:

$$\text{For } t<0, \text{ all } C=1 \quad (10)$$

For $t>0$,

$$\text{at } Z=0,\ C_b=0 \quad (11)$$

$$\text{at } Z=0,\ W_eC_e=\frac{DV_e}{L^2}\frac{\partial C_e}{\partial Z} \quad (12)$$

$$\text{at } Z=1,\ \frac{\partial C_e}{\partial Z}=0 \quad (13)$$

The choice of boundary conditions for the top and bottom of the emulsion phase was a difficult one. The two that were finally adopted are the same as those used by Danckwerts (*4*) and by Wehner and Wilhelm (*17*) for related problems.

Equations 7 to 13 were solved numerically with the aid of an IBM 650 computer. Figures 13 to 15 show the calculated relations between the slope of the decay curve and the various parameters involved. Analytical solutions for the equations have been obtained for certain special cases, and these have been used as a check on the numerical solution. Somewhat similar equations were solved by Anzelius (*1*) for a problem in heat transfer, and by Hougen and Marshall (*11, 12*) for a problem in gas adsorption. The problems solved were limited cases of Equations 7 and 8. **Decay curve slopes** have been obtained from the graphical solution presented by Hougen and Watson (*12*), Figures 216 and 216A. They check the slopes shown in Figures 13 to 15 reasonably well (for the lowest mixing rate curve only, and correcting for the bubble gas volume).

Time-of-contact data. The time of contact experiment requires great care to get good data. In working up the data, two quantities were always obtained—the slope of the straight line on semilogarithmic coordinates, and a material balance. It can easily be shown that the area under the decay curve is the average residence time of the gas in the bed. This can also be calculated from other experimental data—the volume of gas between the injection and sample points, and the gas flow rate. The times calculated in these two ways should check each other. In actual practice there is always some small difference, but the data were considered acceptable if the difference was no more than 10%. Most cases of trouble could be traced to malfunctioning of the sampling and analytical equipment. In some tests, however, where the time measured by integrating the curve was substantially less than that calculated directly, it was found that part of the bed was actually not fluidized. Diffusion of the helium in and out of this "dead" zone was then so slow that it did not show up on the helium decay curve; the bed behaved as though it had a substantially smaller volume.

Small corrections to the measured data were necessary because of the time lag in getting the gas from the vessel into the mass spectrometer. The size and nature of this time lag were measured in separate experiments. A step function in helium concentration was applied directly to the face of the probe, and the response of the sampling system was measured. The sampling lag was about 3 sec.; average residence times in the fluid beds were in the range of 10 to 100 sec.

Crossflow ratio (and helium decay curve slope) would be expected to increase with bed depth, though not necessarily linearly. Data on the effect of bed height in a 3-in. diam. unit are shown in Table 2. The data for the deep beds (12 ft. and 35 ft.)

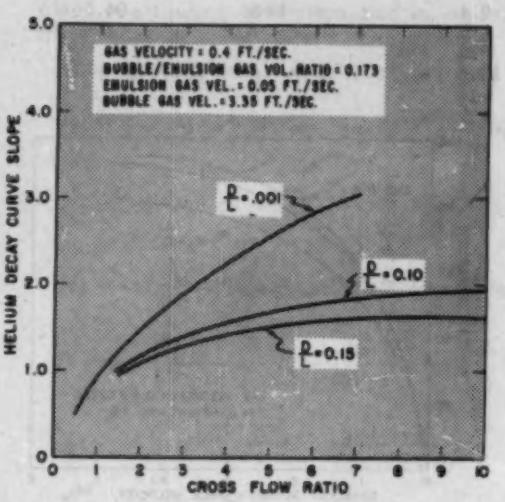

Figure 13. Calculated relation between decay curve slope and cross-flow ratio.

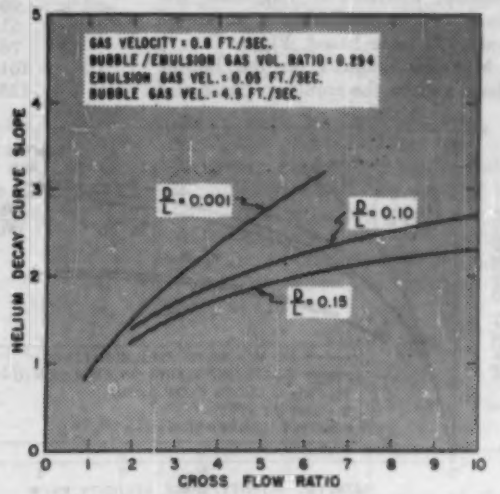

Figure 14. Calculated relation between decay curve slope and cross-flow ratio.

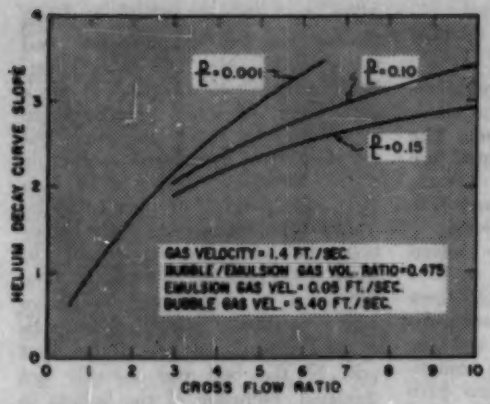

Figure 15. Calculated relation between decay curve slope and cross-flow ratio.

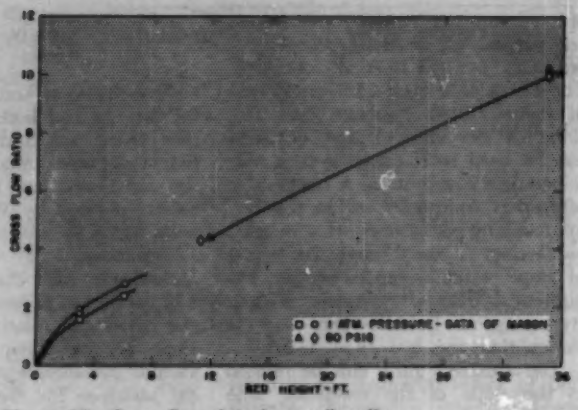

Figure 16. Cross-flow data in small units.

were obtained during this study. The shallow bed data were obtained by Mason *(14)*. The two sets of data are not directly comparable, due to differences in gas pressure and solids properties. In estimating crossflow ratios from Mason's data, the bed properties (V_b/V_e, etc.) were assumed to be those shown in Figure 13, and the mixing rate (D = 0.1 sq.ft./sec. at 0.4 ft./sec. gas velocity), was that measured by Girouard *(8)* for the same particle size. The data are plotted in Figure 16.

Effect on chemical reaction. The object of these tracer experiments was to determine the effect of the fluid bed action on chemical reaction. To do this requires a knowledge of the chemical reaction kinetics—and in fact, is only possible for simple cases. However, very useful information can be obtained by treating the simple case of a catalytic reaction which is first order with respect to the gaseous reactant. This can be done using the same model on which the tracer experiments were based, Figure 3.

Material balances on the bubble phase and on the emulsion phase and on the exit gas lead to the following equations: 14, 15, 16, 17, 18, 19.

$$\frac{\partial C_b}{\partial Z} = \frac{W_e}{W_b}(C_e - C_b) \qquad (14)$$

$$D\frac{V_e}{L^2}\frac{\partial^2 C_e}{\partial Z^2} - W_e\frac{\partial C_e}{\partial Z} + W_e(C_b - C_e) = kGC_e \qquad (15)$$

$$(W_b + W_e)C_2 = W_b C_{b_2} + W_e C_{e_2} \qquad (16)$$

The boundary conditions are:

$$\text{at } Z = 0, \quad C_b = C_1 \qquad (17)$$

$$\frac{\partial C_e}{\partial Z} = \frac{-W_e(C_1 - C_e)}{\frac{DV_e}{L^2}} \qquad (18)$$

Table 2. Crossflow ratios in 3-in. diam. units

Gas vel.	Gas press.	Bed Height 3 Ft.* He Slope	3 Ft.* W_e/W_b	6 Ft.* He Slope	6 Ft.* W_e/W_b	12 Ft. He Slope	12 Ft. W_e/W_b	35 Ft. He Slope	35 Ft. W_e/W_b
0.4	1 atm.	1.2	1.8	1.54	2.8				
0.4	1 atm.	1.25	1.9						
0.4	80 psig					2.3	4.3	4.6	>10
0.8	1 atm.	1.2	1.6	1.54	2.4				
0.8	1 atm.	1.25	1.65						
0.8	80 psig					2.55	4.4	4.6	>10

* Data of Mason *(14)*. Microspherical cracking cat.

Size Ranges

Mason's Data Size, microns	Wt. %	Author's Data Size, microns	Wt. %
0-25	0	0-40	3.8
26-50	0.4	40-80	94.7
51-75	5	80+	1.5
76-100	29		
101-125	51.6		
125-150	14		

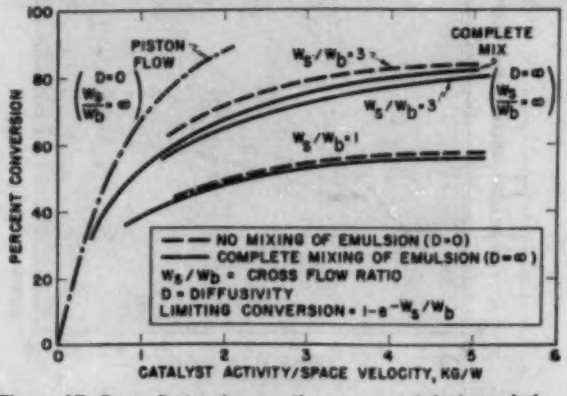

Figure 17. For a first-order reaction, more catalyst needed if cross-flow ratio is low, or if backmixing is rapid.

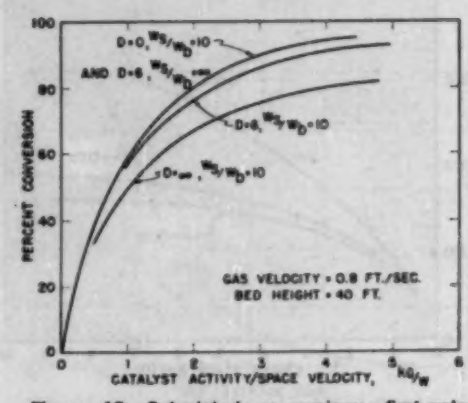

Figure 18. Calculated conversions, first-order reaction.

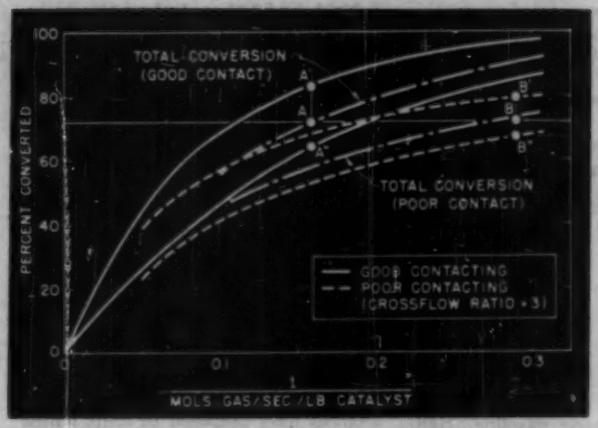

Figure 20. Two first-order reactions with different rate constants: contacting affects selectivity.

$$\text{at } Z=1,\ \frac{\partial C_e}{\partial Z}=0 \qquad (19)$$

These equations are very easily solved for the limiting cases of no backmixing or complete backmixing. For intermediate cases the fraction of reactant converted varies with four dimensionless parameters: an "intensity" parameter (which always shows up for first order reactions), $g = kG/W_b$; two mixing parameters, $b = W_eL^2/DV_e$ and $d = W_bL^2/DV_e$; and a crossflow ratio, $a = W_s/W_b$. 20, 21, 22, 23, 24, 25, 26.

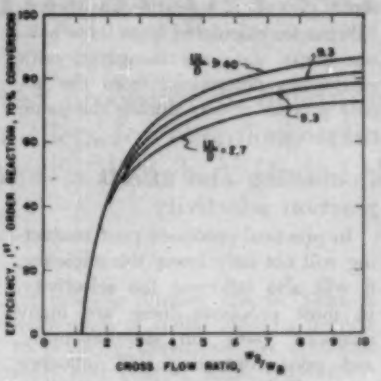

Figure 19. Low cross-flow hurts efficiency.

The solution is:

$$f=1-\frac{\frac{M_1}{P}e^{\alpha_1}\left[\frac{ad}{a+\alpha_1}+b\right]+\frac{M_2}{P}e^{\alpha_2}\left[\frac{ad}{a+\alpha_2}+b\right]+\frac{M_3}{P}e^{\alpha_3}\left[\frac{ad}{a+\alpha_3}+b\right]}{b+d} \qquad (20)$$

where f = fraction conversion, and α_1, α_2, and α_3 are the roots of the cubic equation:

$$R^3+(a-b)R^2-(ab+ad+gd)R-adg=0 \qquad (21)$$

$$M_1=(\alpha_2-b)\alpha_3e^{\alpha_3}-(\alpha_3-b)\alpha_2e^{\alpha_2}+\frac{ab}{a+\alpha_2}\alpha_3e^{\alpha_3}-\frac{ab}{a+\alpha_3}\alpha_2e^{\alpha_2} \qquad (22)$$

$$M_2=(\alpha_3-b)\alpha_1e^{\alpha_1}-(\alpha_1-b)\alpha_3e^{\alpha_3}+\frac{ab}{a+\alpha_3}\alpha_1e^{\alpha_1}-\frac{ab}{a+\alpha_1}\alpha_3e^{\alpha_3} \qquad (23)$$

$$M_3=(\alpha_1-b)\alpha_2e^{\alpha_2}-(\alpha_2-b)\alpha_1e^{\alpha_1}+\frac{ab}{a+\alpha_1}\alpha_2e^{\alpha_2}-\frac{ab}{a+\alpha_2}\alpha_1e^{\alpha_1} \qquad (24)$$

$$P=\alpha_1e^{\alpha_1}\left[\frac{a}{a+\alpha_2}(\alpha_2-b)-\frac{a}{a+\alpha_3}(\alpha_3-b)\right]$$
$$+\alpha_2e^{\alpha_2}\left[\frac{a}{a+\alpha_3}(\alpha_1-b)-\frac{a}{a+\alpha_1}(\alpha_3-b)\right]$$
$$+\alpha_3e^{\alpha_3}\left[\frac{a}{a+\alpha_1}(\alpha_2-b)-\frac{a}{a+\alpha_2}(\alpha_1-b)\right] \qquad (25)$$

Typical calculated results for a first order reaction are shown in Figures 17 and 18. Curves for the easily treated cases of piston flow of the gas, and a completely stirred reactor, are included for comparison. Figure 18 includes a curve for infinite crossflow, calculated using the mixing equation given by Danckwerts (4).

Several interesting observations can be made based on these theoretical curves:

1. With low cross-flow ratios, backmixing has essentially no effect.

2. Despite the very high mixing rates measured in large diameter beds, these beds are far from being completely mixed as far as the reaction is concerned. In fact, the calculations indicate that the conversions are closer to those expected for no mixing than for complete mixing.

3. The deviation from ideal behavior (piston flow) is greater at high conversion levels than at low. This has been pointed out clearly by others (7).

In the model used for these calculations, it has been assumed that all the reaction occurs in the emulsion phase. With this assumption there is a maximum possible conversion which is set by the crossflow ratio; a crossflow ratio of anything less than infinity means that some of the reactant never comes in contact with any catalyst. The ceiling conversion can be shown to be:

$$f_{\text{ceiling}}=1-e^{-W_s/W_b} \qquad (26)$$

This does not conform to experimental data; none of the gas escapes contact with the catalyst completely. It is a simple matter to modify the model by assuming some catalyst inside the bubbles. Calculations show that catalyst inside the bubbles can have a significant effect when the crossflow ratio is low, or when the conversion level is high; it is unimportant when the crossflow ratio is high. There was no direct way of determining catalyst inside the bubbles, and it was generally omitted in calculating reaction results.

As a convenient way of referring to the effect of contacting on the reaction, an "efficiency" has been used, defined as follows:

(See following page.)

This efficiency will depend on the conversion level; in discussing the effect of fluid contacting, a conversion level of 70% has arbitrarily been chosen.

Figure 19 shows the effect of the fluid contacting on efficiency. Efficiency will increase with crossflow up

$$\text{Efficiency} = \frac{\text{Wt. of Catalyst Required for Piston Flow}}{\text{Wt. of Catalyst Required in the Actual Unit}} \times 100\%$$

to a ceiling set by the mixing rate. For a given mixing rate there is a crossflow ratio beyond which there is little further incentive to go; that is, with large increases in crossflow beyond this point there is little further gain in efficiency possible. Backmixing has negligible effect when the crossflow ratio is low, but becomes significant when the crossflow ratio is high.

These calculations were made for the ideal case of simple first-order chemical reaction. Practically all commercial reactions are more complicated than this, and the efficiency depends not only on the fluid mechanics of the bed, but also on the particular chemical reaction kinetics involved. Calculations have been made for more complicated cases by assuming the overall reaction to be made up of a number of first-order reactions proceeding in parallel. Data for one of them are shown in Table 3. The reaction involved was the reforming of

Table 3. Contacting efficiency in a fluid reactor

Helium Decay Slope	Octane No. of product	Efficiencies Relative To A Pilot Unit: Process Results	Efficiencies Relative To A Pilot Unit: From He Decay
1.37	95	80	82
1.95	97.4	75-85	80

a heavy naphtha to make a highly aromatic high octane gasoline. Helium decay data taken during two different periods of operation are shown. Efficiencies calculated from these helium decay data are compared with efficiencies determined from the actual process results during the same two periods.

Contacting also affects reaction selectivity

In practical processes poor contacting will not only lower the effciency, it will also influence the selectivity. In most processes there are many reactions going on simultaneously, and poor contacting will influence some of these reactions more than others. One way in which this can occur is illustrated in Figure 20. Conversions are shown for two first-order reactions proceeding in parallel. The two reactions have different rate constants, and differ in conversion level. Conversions are shown for two different reactors, one of them having good contacting and the other poor contacting. With good contacting and a given set of reaction conditions, the individual conversions are shown at A′ and A″. The total conversion for this case, which depends on the proportion of the two materials in the feed, is shown at A. With poor contacting it is still possible to obtain the same total conversion, though it requires more catalyst (point B). However, the individual conversions, shown at B′ and B″, have changed. There is less of the reactive material converted (B′ is less than A′), and more of the unreactive material converted (B″ greater than A″).

The general trend illustrated will always be the direction of the effect of poor contacting. It will reduce differences due to chemical activity. Ultimately, if the contacting were bad enough, everything that got into the emulsion would be converted. In that case, differences due to chemical reaction would disappear and all materials would be reacted to the same extent.

Table 4. Effect of contact on selectivity.

Helium Slope	Octane No.	Conversions: Naphthenes	Conversions: Paraffins	Yield Credit
2.5	88	69	52	1.5%
1.4	88	65	57	Base

This type of behavior has been observed in fluid hydroforming, Table 4. The table gives the results of type analysis data obtained in units which were running under essentially the same operating conditions, but in which the contacting, as measured by helium decay curves, was substantially different. For a given octane number, poor contacting leads to a lower naphthene conversion and a higher paraffin conversion; that is, poor contacting has narrowed the difference in conversion between the reactive naphthenes, and the less reactive paraffins. In the case of fluid hydroforming, naphthenes are converted to aromatics much more quantitatively and with less gas production than paraffins. Thus, when the naphthene conversion is reduced and paraffin conversion correspondingly increased, the overall yield suffers.

NOTATION

- C = Concentration, weight/cu. ft.
- D = Diffusion coefficient, sq. ft./sec.
- G = Weight of catalyst in the bed, lb.
- k = First-order reaction rate constant.
- L = Bed length, ft.
- t = Time, sec.
- U = Gas velocity, ft./sec.
- V = Gas volume in the bed, cu. ft.
  - V_b = Bubble gas volume.
  - V_e = Emulsion gas volume.
- W = Gas flow rate through the bed, cu. ft./sec.
  - W_b = Bubble gas flow.
  - W_e = Emulsion gas flow.
  - W_s = Total crossflow in the bed.
- X = Bed depth measured from the top of the bed, ft.
- Z = Fraction of bed height, from the bottom.

Subscripts:

- 1 = At the entrance to the bed (bottom).
- 2 = At the exit from the bed (top).
- b = Bubble.
- e = Emulsion.
- s = Crossflow.

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Radial thrust in Centrifugal pressure pumps

A practical test procedure to determine the radial load on overhung impellers for chemical, refinery, and reactor circulating pumps is described. Radial thrust values are also given.

CENTRIFUGAL PUMPS have been designed and built for many years but today more information relating to radial thrust is needed. Where pumps are run at relatively low speeds and operated almost exclusively near peak efficiency, the problems resulting from radial thrust are normally not important. However, in refinery and chemical plant process pumps, which are frequently required to operate at far from the maximum efficiency point, and frequently at 3500 rpm, radial thrust becomes a significant design factor in determining the sizes of bearings and shafts *(1)*. For proper operation of mechanical seals and packing, a minimum shaft deflection is required but at the same time a minimum shaft diameter is desirable to get the lowest possible rubbing speeds. Thus, a knowledge of radial loads is needed to properly determine the optimum shaft and bearing sizes. On canned motor pumps used in the chemical industry, and for reactor circulating pumps in atomic power plants, the bearings are frequently lubricated by low-viscosity fluids. Therefore, an accurate knowledge of radial loads is imperative.

Although there is good theory available to design a centrifugal pump for the right head-capacity and efficiency, it has long been standard practice to verify any designs by tests on actual pumps. Approximations can be made of the radial load on an impeller but the empirical constants related to side thrust vary widely with different volute designs and probably with different impeller designs. Some high velocity single volute pumps have relatively large radial thrust values. Lower velocity volutes with different proportions can appreciably reduce this value.

There is a need for more published data to aid the designer in his initial design but radial load tests should be made on all new designs as an integral part of the pump testing procedure.

Methods of measurement

Three methods of determining the radial thrust load were studied in an attempt to select the most practical

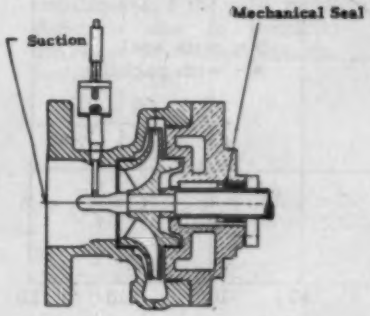


Figure 2. Probes located in front of the impeller.

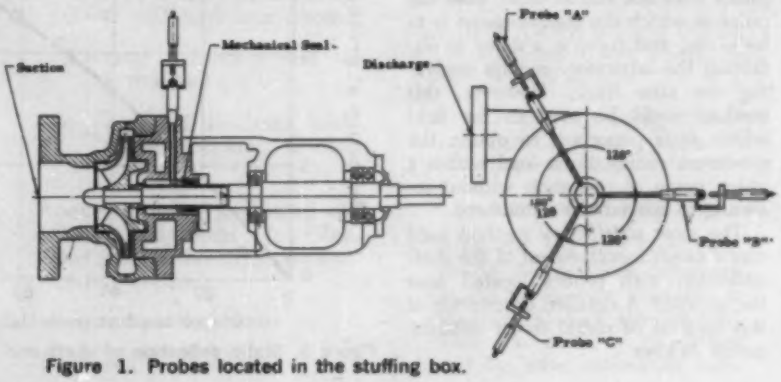


Figure 1. Probes located in the stuffing box.

. . . radial thrust load measured by an hydraulic pressure survey in the volute, the persulfated bearing method, and the mechanical probe method.

one. They included: a hydraulic pressure survey in the volute, the persulfated bearing method, and the mechanical probe method.

Hydraulic pressure method. In the hydraulic pressure method, static pressure taps were located around the periphery of the impeller and the static pressure distribution curve around the volute was measured when the pump was operated at various capacities. From these data pressures were plotted at 10° intervals around the volute. The vectors were then added to give the magnitude and direction of the unbalanced radial load at each capacity point. This method makes the volute unserviceable for restocking, requires many readings to be taken at each capacity point, requires tedious vector analysis from the data plotted, does not indicate dynamic unbalance, and gives values of the same order of magnitude but lower than those obtained by other methods.

Persulfated bearing method. The second type of measurement made use of special ball bearings with persulfated races so that the load track could be readily measured. After a run of 20 min. at what was anticipated to be the maximum radial load point, the pump was carefully disassembled and the bearings sent to the laboratory of the bearing manufacturer for analysis. Measurement of the load track then yielded a good indication of the load on the bearings. The impeller radial thrust could be calculated from these values.

This method measured both hydraulic and mechanical unbalance and gave higher values than was obtained by the pressure method but had several serious limitations: a new bearing must be used for each capacity point; great care must be used so that the pump does not run at other than the point at which the measurement is to be made; and there is a delay in obtaining the laboratory reports analyzing the race track. However, this method could be used in the field where it is important to obtain the maximum radial thrust load within a given range of operation without resorting to special test equipment.

The most satisfactory method used was a direct measurement of the shaft deflection with probes located near the impeller. A detailed description of this method of radial thrust determination follows.

Probe method. Mechanical probes can be used to measure shaft deflection and to determine radial forces on centrifugal impellers by measurement either in the stuffing box area near the back of the impeller, or at a special impeller nut in front of the impeller.

Probes in the stuffing box do not interfere with the flow of the pump. They were used when they could be located at least half way between the impeller and inboard bearing, Figure 1. They were located as close to the impeller as possible to increase the magnitude of the deflection readings, and to reduce the correction to impeller centerline. Values obtained by measuring the deflection of a special impeller nut by probes through the suction area of the pump were used when probes could not be located at least half way to the impeller as shown in Figure 2.

Three probes were spaced 120° apart and the total deflection was determined from the three components. Some readings were taken with two probes spaced at 90°, where three would not fit in the pump backplate. However, when only two probes were used the effect of dynamic unbalance was eliminated by taking zero readings when the pump was run without water. Because the dynamic balance may be affected by water in the impeller, a dry run is not a perfect measure of the dynamic unbalance during pumping.

Mechanical seals were used in the pumps to avoid possible shaft support which might have occurred if packing were used. Check tests showed no effect of packing support where shaft deflections were under 0.020 in. at the stuffing box, Figure 3. Impeller wearing clearances were always kept appreciably greater than the shaft deflection.

The test procedure was as follows:

1. The pump was stopped and the shaft rotated by hand while the probes were screwed in to just touch the shaft.
2. Micrometers were read indicating the location of the probes in the static position.
3. The probes were backed away from the shaft, the pump started and operated until a steady state was reached at the desired capacity point.
4. The probes were screwed down until contact with the shaft was evident by touch. (Experiments were run to determine if insulated probes with electrical contacting indicators gave more accurate results than mechanical "feel" of the probe. Experience showed that little difference was obtained in the readings determined by electrical indication vs. "feel".)
5. The micrometers showed the

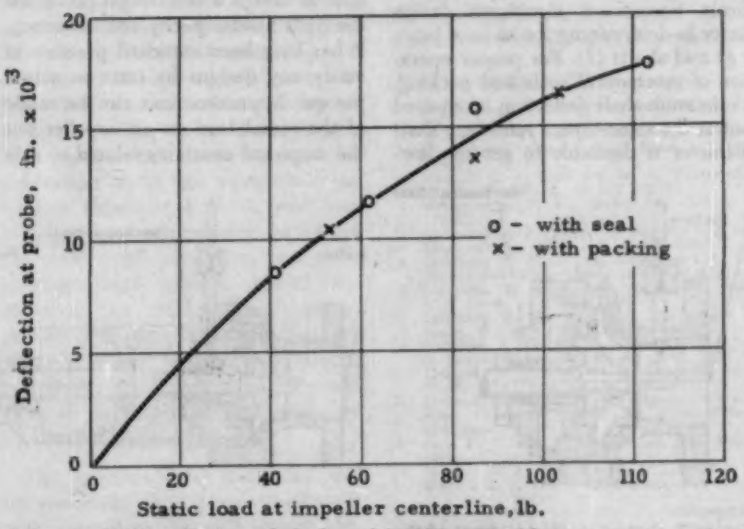
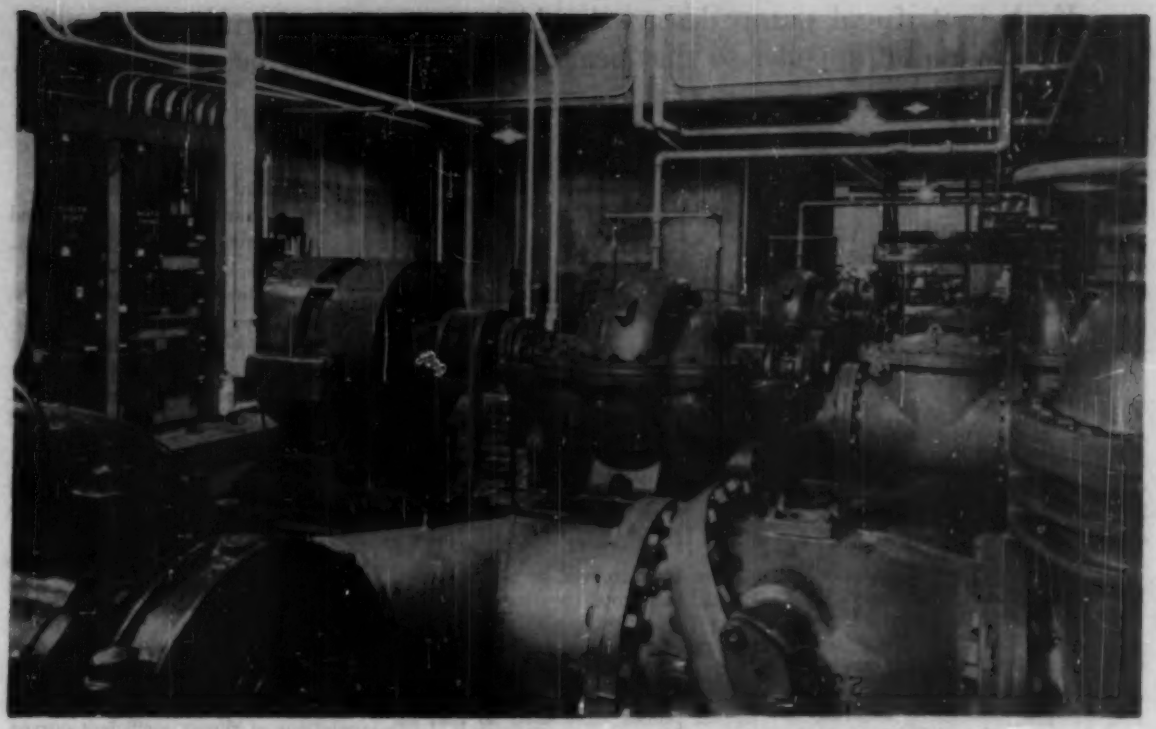


Figure 3. Static deflection of shaft and bearing assembly.



Centrifugal pumps each capable of delivering 10,000 gal./min. of screened water without booster pumps.

running contact position of the probes and these values were recorded for the capacity of operation. Probes were unscrewed away from the shaft.

6. The pump was then stopped and the zero position of the probes rechecked with the shaft rotated by hand. If any discrepancy with the initial zero position was noted, the test was rerun. It was found worth the time and effort to start the pump for each reading because of wear of the probes if several operating conditions were measured between static checks.

7a. *Three-probe calculations:* (Figures 1 and 2)

The deflection due to dynamic unbalance and the total radial deflection due to hydraulic forces can be obtained from the probe readings:

$$D = \frac{A' + B' + C'}{3}$$

$$R = \frac{2}{\sqrt{3}}\sqrt{A^2 + B^2 + AB}$$

$$= \frac{2}{\sqrt{3}}\sqrt{C^2 + B^2 + BC}$$

$$= \frac{2}{\sqrt{3}}\sqrt{A^2 + C^2 + AC}$$

$$\tan\theta = \frac{2A+C}{\sqrt{3}C} = \frac{2B+C}{\sqrt{3}C} = \frac{2C+A}{\sqrt{3}A}$$

where

D = radius of shaft deflection due to dynamic unbalance while pumping.

A' = reading of probe A.

B' = reading of probe B.

C' = reading of probe C.

$A = A' - D$, $B = B' - D$, $C = C' - D$ } readings corrected for dynamic unbalance to give deflection caused by hydraulic forces.

R = total deflection due to hydraulic forces.

θ = angle of resultant with probe indicated in denominator.

Above formulas are based on outward movement of probes being the positive direction and negative inward.

7b. *Two-probe calculations:*

$$R = \sqrt{X^2 + Y^2}$$

$$\tan\theta = \frac{Y}{X}$$

$$D' = \frac{X_0 + Y_0}{2}$$ = radius of shaft deflection due to dynamic unbalance when pump is run with no fluid in impeller.

R = total deflection due to hydraulic forces.

X_0 = X probe reading on dry run.

Y_0 = Y probe reading on dry run.

X = X probe reading during deflection test where X_0 is used as zero.

Y = Y probe reading during deflection test where Y_0 is used as zero.

θ = angle of "R" with X axis.

8. After the test had been completed, the measured deflections at the probe were corrected to the centerline of the impeller. This was done by calculation and by static calibration tests.

. . . Each centrifugal pump design should be tested to determine the radial thrust loads at the impeller so that bearings and shafts can be properly sized.

a) For probe in suction area, Figure 2.

$$R_{\text{¢}} = \frac{R_s\left(\frac{b^3}{I_b} + \frac{a^3-b^3}{I_a} + \frac{a^2l}{I_l}\right)}{\left(\frac{b^3}{I_b} + \frac{a^3-b^3}{I_a} + \frac{a^2l}{I_l}\right) + \frac{3}{2}\left(\frac{b^2X}{I_b}\right) + \frac{3}{2}\left[\frac{X(a^2-b^2)}{I_a}\right] + \frac{alX}{I_l}}$$

b) For probe in stuffing box area, Figure 1.

$$R_{\text{¢}} = \frac{R_s\left(\frac{b^3}{I_b} + \frac{a^3-b^3}{I_a} + \frac{a^2l}{I_l}\right)}{\left(\frac{b^3}{I_b} + \frac{a^3-b^3}{I_a} + \frac{a^2l}{I_l}\right) - \frac{3}{2}\left(\frac{b^2X}{I_b}\right) - \frac{3}{2}\left[\frac{X(a^2-b^2)}{I_a}\right] - \frac{alX}{I_l} + \frac{X^2}{2I_b}}$$

The above formulas assume no support from a shaft sleeve and are more accurate if the sleeve is eliminated. They also neglect any bearing deflection.

Experience has shown that it is simpler and more accurate to measure the deflection of the shaft at the impeller centerline and at the probes, while statically loading the shaft at the impeller centerline with known weights. A plot of deflection at probes and impeller centerline can be made, and this data used for correction of probe readings. This procedure takes into account sleeve stiffness and bearing deflections.

9. The radial force at the impeller was calculated from the deflection at the point by the following formula:

$$W = \frac{R_{\text{¢}}\ 3E}{\frac{b^3}{I_b} + \frac{a^3-b^3}{I_a} + \frac{a^2l}{I_l}}$$ (*1*: formula 19B)

With an alternate and more accurate method, the radial force on the impeller was determined by a static shaft calibration test. A typical curve showing deflections at the probe vs. force applied at the impeller centerline is shown in Figure 3. From this calibration curve the force at the impeller was determined directly for any probe measurement. The effect of sleeve and bearing deflections are taken into account by this method.

Although there are many possible ways of making probes, the greatest success was achieved by use of probes which had good bearing characteristics (a bronze tip) to prevent galling or vibration on contact. It was thought that a number of starts and stops could be eliminated if hard-tipped probes were used so that no wear would occur. However, the use of a carboloy tip caused scoring and galling on the sleeve and was not as satisfactory as bronze. Micrometers proved much more satisfactory than dial gauges to measure probe positions because they were unaffected by the pump vibration.

Test results

Test results on five different pump designs are shown in Figures 4-7. The radial thrust coefficient K *(2)* has been plotted against percent of design capacity which is the capacity at maximum efficiency point.

$$K = \frac{2.31\,F}{D_2\,B_2\,S\,H}$$

where

K = radial thrust coefficient.
F = hydraulic radial unbalanced force at impeller centerline, lb.
D_2 = outside diameter of impeller, in.
B_2 = over-all width of impeller at periphery, in.
H = total pump head of pump, ft.
S = specific gravity of the liquid pumped.

All the single and double volute pumps tested were designed to give constant velocity throughout the volute. The diffusor pump had a 13-vane diffusor inside a constant-velocity type case. Basic pump characteristics are shown in Table 1.

The three single volute pumps with constant velocity designs show wide variations of thrust coefficient curves. Repeated tests and dynamic balancing of impellers did not affect the basic shape or magnitudes of the curves. Therefore, the differences must be the result of different designs required to get the specific speed and other characteristics required for different pump applications. It is not possible to use a single, radial thrust coefficient curve for all constant velocity single volute pumps. Specific speed, volute velocity, and many detailed impeller and volute design characteristics must affect the thrust coefficient.

The use of a diffusor is no assurance that the thrust coefficient will be low. The pump described in Table 1 is

Table 1. Pump characteristics.

Pump	Type Case	N_s	Design Capacity gpm	Design Head feet	Test Speed	Impeller % Full Diameter	Type Impeller
A_1	Double volute	2640	2500	107	1760	100	Single suction
A_2	Double volute	2880	2250	89	1760	93.5	Single suction
B	Diffusor	3960	2700	168	3560	98	Double suction
C	Single volute	610	350	520	3550	100	Single suction
D	Single volute	1490	580	215	3500	100	Single suction
E	Single volute	1250	800	340	3500	100	Single suction

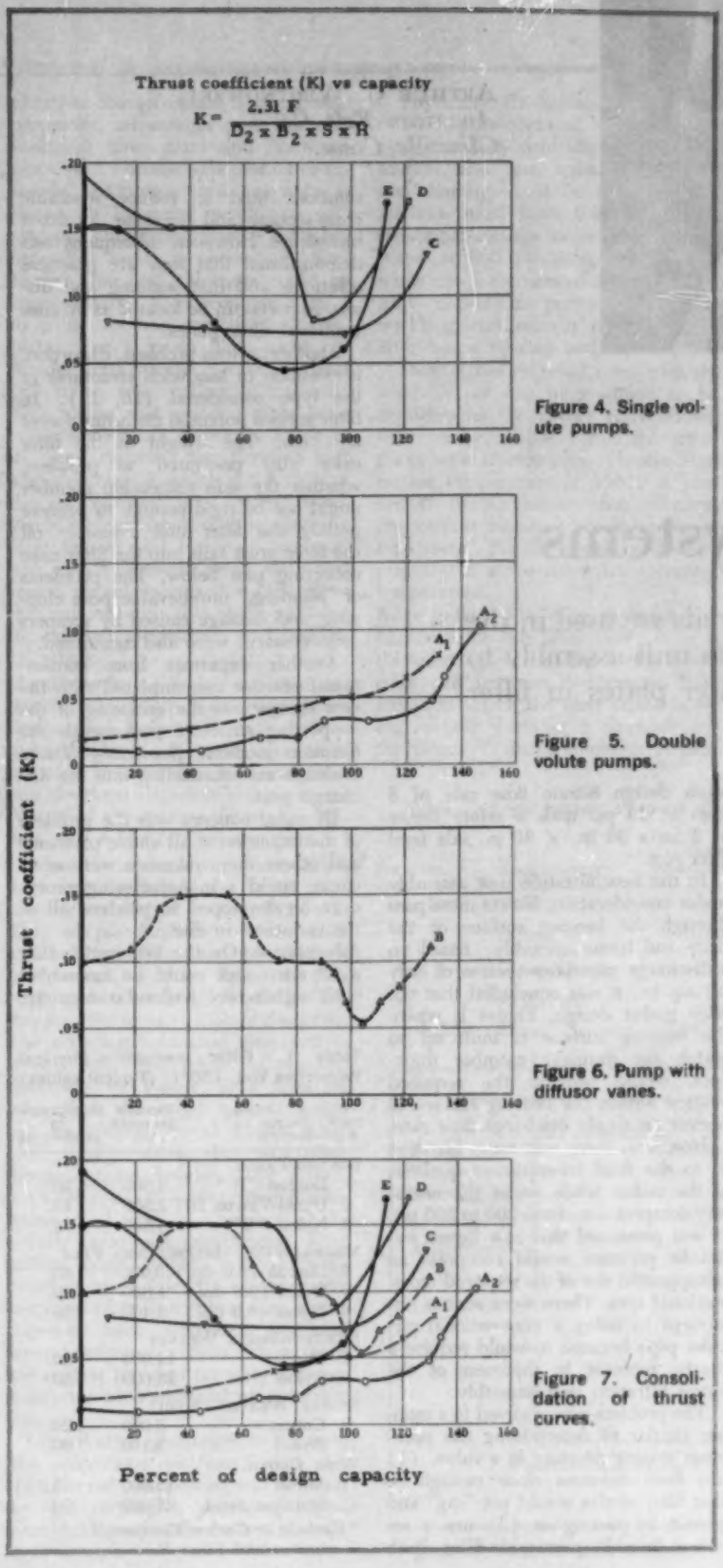


Figure 4. Single volute pumps.

Figure 5. Double volute pumps.

Figure 6. Pump with diffusor vanes.

Figure 7. Consolidation of thrust curves.

obviously not well designed for minimum radial thrust and has values as high as two of the single volute pumps. A test not shown was made with the diffusor removed. It indicated that this diffusor did no good except below 50% of design capacity. It was of real value in this low capacity region.

The double volute pump had the lowest thrust coefficient of any of the pumps tested. It was particularly good at capacities less than normal.

It should be noted that the thrust coefficient on all pumps rises sharply at capacities larger than design point. For many applications the maximum radial loads will also occur at high capacity points even though the head is low. The unstable flow that occurs due to cavitation at high capacity points, combined with high radial thrust values, can cause serious operating trouble if cavitation exists. Thus, to determine shaft and bearing sizes both low and high capacity operation of the pump must be carefully considered.

Conclusions

1. Radial thrust coefficients of centrifugal pumps vary widely even with the same type of volute design.

2. It may be highly inaccurate to apply thrust coefficients determined for one specific pump to another design.

3. Each centrifugal pump design should be tested to determine the radial thrust loads at the impeller so that bearings and shafts can be properly sized.

4. The probe method described in this paper is one practical method of determining shaft deflection and bearing loads.

5. A well designed pump is one which has the proper size of shaft and bearings for the radial load exerted by the impeller. This can only be obtained by measuring the loads involved and designing the shafts and bearings accordingly.

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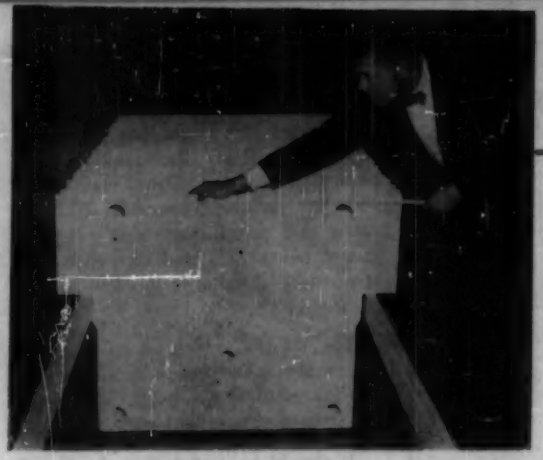

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American Felt Co.
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Unified filtration systems

Modern synthetic materials are used in the design of a new filtration unit assembly to replace conventional filter plates in filter presses.

THE TRADITIONAL FILTER PRESS (*4, 7, 9*) has widespread application in the various chemical process industries. Compared to other types of filters, the filter press yields the driest cake, has the lowest cost, and requires the least floor space per square foot of filtration area (*8, 12*). It is versatile, easy to assemble, repair, maintain, and inspect.

A basic improvement, in the form of a compact, one-piece combined filter unit and medium, has resulted from studies made at the American Felt Co. to overcome some or all of the above disadvantages.

New design features are based on modern, synthetic materials of construction. One of the premises of this work was recognition that the conventional filter leaf assembly (*15*) needs modification to permit a bearing surface to have gasket action, conventional feed and washing ports, rests, alignment guides, and discharge ports, Figure 1. As new construction materials were being used it was important that analysis of over-all hydraulic design, specifically that of the drainage member and discharge port, be undertaken.

It was found by calculation, and confirmed by test, that a circular orifice with a cross-section of 0.1 sq. in. would satisfactorily handle a maximum design filtrate flow rate of 8 gpm at 30 psi with a safety factor of 2 for a 30 in. × 30 in. side feed filter plot.

In the new filtration unit assembly under consideration, filtrate must pass through the bearing surface of the plate and frame assembly. Based on a discharge port cross-section of only 0.1 sq. in., it was concluded that the edge gasket design, Figure 1, where the bearing surface is built up to match the drainage member thickness, would provide the required volume within the bearing surface to permit an ample discharge flow rate.

However, there was some question as to the fluid transmission qualities of the orifice while under the necessary compression—from 200 to 500 psi. It was presumed that raw liquor hydraulic pressure would compress an unsupported slot of the required cross-sectional area. There were serious objections to using a conventional circular pipe because it would require a drastic increase in thickness of the entire filtration unit assembly.

The problem was resolved in a manner similar to determining the minimum seating pressure in a valve: (1) use fixed columns close enough so that filter media would not "sag" and permit by-passing or (2) use a resilient, laterally-permeable filler. Both solutions tend to reduce available cross-section and increase localized turbulence. However, subsequent tests demonstrated that they are practical solutions, and that washing and discharge ports can be located as on conventional filter plates.

Another serious problem, distortion, is common in sandwich structures of the type considered (*10, 11*). In filter presses potential distorting forces are high. The weight of the filter cake also presented a problem, whether the side suspension member might not be rigid enough to prevent pulling the filter unit assembly off the filter press rails into the filter cake collecting pan below. The problems of "blinding," unrelievable pore clogging, and damage caused by scrapers (if necessary) were also considered.

Another departure from conventional practice contemplated with the new design was the enclosing of the supporting structure underneath the filtration medium, permitting filtrate drainage and channeling into the discharge port.

Of equal concern was the problem of manufacture; if all above problems and others then unknown were overcome, could a manufacturing procedure be developed to produce all of the variations in design?

Advantages: On the assumption that a filtration unit could be assembled with satisfactory hydraulic capacity,

Table 1. Filter medium: Physical Properties Wet, 150°F. (Typical values)

Item No.	Filter Medium	Tensile Strength psi	Elongation % at Rupture
	Bonded Fabric		
1.	Dacron—"B"*	6,500	50.
2.	Dynel-Vinyon HH	1,500	40.
3.	Nylon—"B"*	3,500	73.
	Mechanically Interlocked Felt		
4.	Dacron (6.0 dpf)	3,000	60.
5.	Dynel (3.0 dpf)	1,300	40.
6.	Nylon (6.0 dpf)	3,400	30.
	Multifilament Weaves		
7.	Dacron	19,000	30.
8.	Nylon	13,000	30.
	Staple Weaves (Spun)		
9.	Cotton	5,000	20.
10.	Dynel	3,100	60.
	Wire Cloth		
11.	Monel	15,000	3.
12.	Stainless Steel	25,000	10.

* *Carbide & Carbon Company's experimental Fiber B.*

filtration characteristics, and physical properties, advantages over the conventional filter plate and cloth arrangement become apparent. For example, a filtration unit assembly as shown in Figure 1 would be self-aligning, eliminating most of the labor normally used in adjusting filter cloths; filter leaf thickness could be approximately ¼ in. compared to 1 to 2 in. for the conventional filter plate. For a given filter press the thinner unit would permit at least 50% more cake collecting capacity. This means that existing filter press equipment could produce 150% of its rated capacity; the filtration unit assembly would weigh 1/10 that of the conventional filter plate, which would reduce labor cost in cleaning filter presses and eliminate hammering; use of synthetic resins and fibers would permit construction of a filtration unit assembly that could be stable to chemical, electrolytic, and biological attack.

Manufacturing: A basic premise of this work is that the proposed edge gasket design will permit all normal filter plate functions. By using the built-up edge method the proposed filter unit develops a thick bearing surface, controlled filtrate flow, filter unit stiffness, and a filtrate discharge port.

After the materials of construction have been selected, the basic components are die cut to size, Figure 2. They are placed on top of each other and indexed. The assembly is then heat sealed. In this operation the edge gasket receives all of the hot compressive force, which is desirable. The resulting laminated filter unit is strong, stiff, and ready to operate. Referring to Figure 2, it can be seen that the edge gasket design can be adapted to all known filter plate configurations. Recessed plate design can be developed by fastening a filter unit to a conventional filter frame.

Only three basic components, filter media, edge gasket, and drainage member, are needed to assemble the proposed plate and frame filter units. However, each component performs several definite functions. Thus, there are explicit physical property requirements for each material of construction.

Contribution of strength to the rests (the projections, or "ears," that rest upon the rails, supporting and aligning the leaf vertically); providing alignment guide and stiffness to the overall filter unit.

Physically, the minimum filter medium requirements of solids separation, based on controlled particle retention, flow rate, cake release, and non-blinding, must be satisfied. The medium must have 0.0% lateral dimensional change in cold or boiling water at 500 psi compressive stress when the conventional filter press is fully closed to prevent filter unit buckling and remain oriented with filter frame bearing surface.

Most of the required properties are available, or can be modified to be available in the newer conventional filter media. Table 1 lists five categories with 12 examples. The elevated testing temperature of 150°F is presented to emphasize that physical property at exposure conditions must be known. For the scope of this report 150°F is the maximum operating temperature.

Edge gasket: The edge gasket is the backbone of the filter unit. It is a thickness spacer bonded at the inner edge and between two precut filter media to match the filter frame bearing surface, forming a chamber for the filtrate drainage member. It provides major strength to the filter unit edges, rests, and alignment guides; it provides a material with high compression energy capacity to maintain "dimension" during filter press compression, or filter frame impact; it forms a closure to seal filtrate; and the edge gasket shape develops channels or dams for the liquid flow pattern. Except that it must be impermeable, the physical property requirements of the edge gasket duplicate those of the filter medium, Table 2.

Drainage member: The function of the drainage member is subtle. Placed between two filter media, it must resist hydraulic compression to the degree of providing adequate lateral, or edgewise permeability for unrestricted filtrate flow. Just as important is the resilient force it exerts on the filter media at the washing and discharge ports, Figure 3, which prevents raw liquor and collected filter cake from seeping across the discharge port into the filtrate.

Applicable physical properties are presented in Table 3. Other desirable physical properties are flatness—to

Table 2. Edge gasket: Physical Properties Wet 150°F. (Typical Values).

Item No.	Edge Gasket	Tensile Strength PSI	Elongation % at Rupture	Lateral Dimension Change % at 2500 PSI 150°F. Wet
	Bonded Fabric			
1.	Dacron "B"*	10,000	60	0.0
2.	Dynel-Vinyon	4,500	50	0.0
3.	Nylon "B"*	8,500	50	0.0

* *Carbide & Carbon Company's experimental Fiber B.*

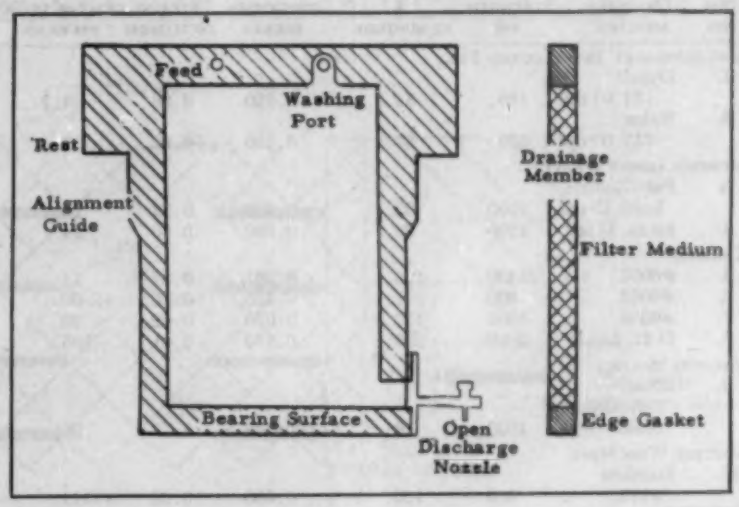

Figure 1. Filtration unit assembly.

minimize filter media molding, and high tensile strength and low elongation—to strengthen the final filter unit.

Materials of construction

Cast iron and wood are conventional materials of construction for filter press plates. For corrosive use rubber covered cast iron, phenol-formaldehyde, and polyester resins are used. Filter media used on these plates include cotton, Dacron, nylon, Dynel, wire cloth, and filter paper. These materials have proved satisfactory over the years.

In the filter unit under consideration, practically any of the new materials of construction could be used after they have been made dimensionally stable. Special attention is given to the field of synthetic fibers and resins. This class presents a wide variety of materials whose outstanding properties are strength and chemical stability.

Mechanically interlocked felt manufactured from coarse staple fibers develop substantial lateral permeability at given degrees of compressive stress. Monofilament weaves of 15 mil diameter filaments develop high lateral permeability through a broad compression range. Permeability is a result of crossing filaments which form small channels. An advantage is high tensile strength which, by assembly, can be transmitted to filter unit strength.

Trilock* is an interesting material in this category. It is manufactured by shrinking special monofilaments to form a highly resilient and permeable woven channel or ducts.

By vacuum molding plastic sheet to form corrugations or pyramids, a drainage field similar to a conventional filter unit can be made. However, the uneven corrugated or pyramid surface places unnecessary stress on the filter media.

Crimped, stainless woven wire mesh, has very good resilient and lateral permeability properties.

* *U. S. Rubber Co. trademark.*

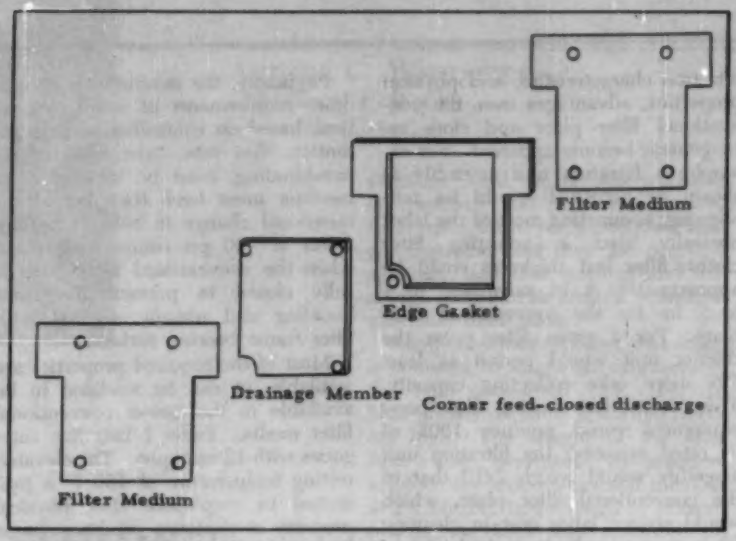

Figure 2. Exploded view of corner feed closed discharge.

Table 3. Drainage member Physical Properties Wet 150°F. (Typical Values).

Item No.	Drainage member	Tensile strength psi	Elongation % at rupture	Compression-Permeability Values Stress—30 psi; 150°F; Wet: Actual thickness inches	Strain inch/inch	Edgewise water Permeability gpm/sq. in/30 psi head
Mechanically Interlocked Felt						
1.	Dynel (24.0) dpf	180.	53.	0.120	0.68	3.2
2.	Nylon (15.0) dpf	250.	67.	0.130	0.62	3.4
Monofilament Weave						
3.	Polyethylene linear 15 mil.	1100	33.	0.090	0.52	24.
4.	Saran, 15 mil.	1100	83.	0.090	0.50	24.
Trilock*						
5.	#6001	1400	123.	0.061	0.37	24.
6.	#6002	800	142.	0.105	0.70	60.
7.	#6008	1300	126.	0.070	0.42	20.
8.	D-21, 233-A	2000	200.	0.130	0.61	105.
Vacuum Molded						
9.	Linear Polyethylene 0.040" thick	4500	10.	0.060	0.75	90.
Knitted Wire Mesh						
10.	Stainless #1121	200	130.	0.080	0.62	111.

* *U. S. Rubber Company trademark.*

Seepage threshold

As part of the edge gasket filter unit design, the resilient force of the drainage member seals raw liquor from the filtrate, Figures 3 and 4. Isolating this problem there are two known or available values; the *hydraulic pressure*, expressed in psi., of the raw liquor (including compressed air used to dry filter cakes) labeled "B" on Figure 3; and the *drainage member force of resilience*, expressed in psi, labeled "A," is available by determining the stress-strain curve of a given material. Although resilient force and hydraulic pressure are expressed in common units (psi) it was not initially conceded that the seepage threshold would be arrived at when both forces were equalized.

That sealing force, in psi, equal to hydraulic pressure, in psi, does represent a seepage threshold condition, was established by plotting of the test results.

Stress-strain curve of drainage members: To establish the resilient force available in a group of typical drainage members, their stress-strain curves were determined, Table 3. In selecting the resilient force the most accurate curve would be given by the equilibrium hysteresis loop and allowance for compressive creep would be made. However, in this work the magnitude of resilient force is needed and the use of a safety factor is anticipated.

Edgewise water permeability: Lateral permeability values of drainage members is needed for general field drainage and for the critical discharge port detail. To obtain usable data for a

given drainage member it is necessary to correlate the lateral permeability against strain.

Basic permeability data were obtained on the materials of Table 3. Edgewise travel of air was one inch, measured by air permeameter, expressed as cfm/cu. in. at a given strain, expressed in in./in. Cfm was converted to gpm by means of the air-liquid permeability conversion graph previously reported by the author (*15*).

In Table 3 the edgewise water permeability is expressed in gpm/sq. in./30 psi, at a stress of 30 psi, 150°F, wet and tabulated against the strain for that value.

Filtrate discharge port design: Data required in designing a filtrate discharge port are: operating hydraulic pressure, required flow rate per filtration unit, lineal inches of available discharge port, and depth of discharge port requiring resilient support.

Washing port

The washing port detail for three-button washing plates is identical to that of the discharge port. The resilient force in this case seals wash water from "short-circuiting" filter cake.

A variety of successful pilot plant tests pointed out that further work with field trials should be made.

Field trial No. 1

The first field trial was made in a rayon plant where diatomaceous earth was being used as filter aid in the removal of iron and zinc salts from an alkaline 30% Na_2SO_4 solution. As this was a new processing operation, previous operating data was not available. Preliminary to the filtration unit assembly trial, a filter medium evaluation was made. The entire filter press, of twenty-four 30 in. × 30 in. side-feed side-discharge plate and frames, was clothed with a bonded fabric made of 20-oz./sq. yd. nylon and Fiber B, (Item No. 3 Table 1.) Nylon and Fiber B were used, for their alkaline stability. Three month's operation demonstrated satisfactory filter media performance.

Operating conditions:

1.	Filtration area, sq. ft.	251
2.	Filter cake volume, cu. ft.	10.5
3.	Flow rate, gpm/sq. ft.	0.25
4.	Viscosity, cp.	12.
5.	Operating pressure, maximum psi	30.
6.	Temperature, °F.	150
7.	Discharge head, ft. of positive head	20.
8.	Alkalinity, pH	12.
9.	Amount of filter aid, lb./batch	50.
10.	Time cycle, hr.	4
11.	Throughput, gal./cycle	3000.
12.	Yield, lb. $Na_2SO_4 + 10H_2O$/cycle	8400.
13.	Value of product/cycle at 17¢/lb. dollars	1428.
14.	Cycles/6 months, total batches	100

A group of four filtration unit assemblies were manufactured using: as filter media, Item 3, Table 1; edge gasket, Item 3, Table 2; two unit assemblies with drainage member, Item 2, Table 3 (referred to as Ex. No. 494); and two unit assemblies with drainage member, Item 4, Table 3 (referred to as Ex. No. 474).

An initial test was run by installing all four assemblies with 20 conventional filter plates. When the filter press was filled with city water, severe leakage developed at the side discharge port on each filter unit assembly. Each of the four experimental units also developed severe leakage in varying degrees at the same place. In spite of this poor performance, one leaf (Ex. 494, with the least amount of leakage) which contained a nylon mechanically-interlocked felt drainage member, remained in place. The other three were replaced by a conventional plate and the 30% Na_2SO_4 liquor was then fed into the filter press. There was only perceptible leakage — a quantity considered normal.

The reduction of leakage was attributed to the increased viscosity of the 30% solution, that is; from 1.0 cp. of water to 12 cp. for the raw liquor. A separate test demonstrated that this viscosity change represented a tenfold reduction in flow rate.

This one unit assembly (Ex. 494)

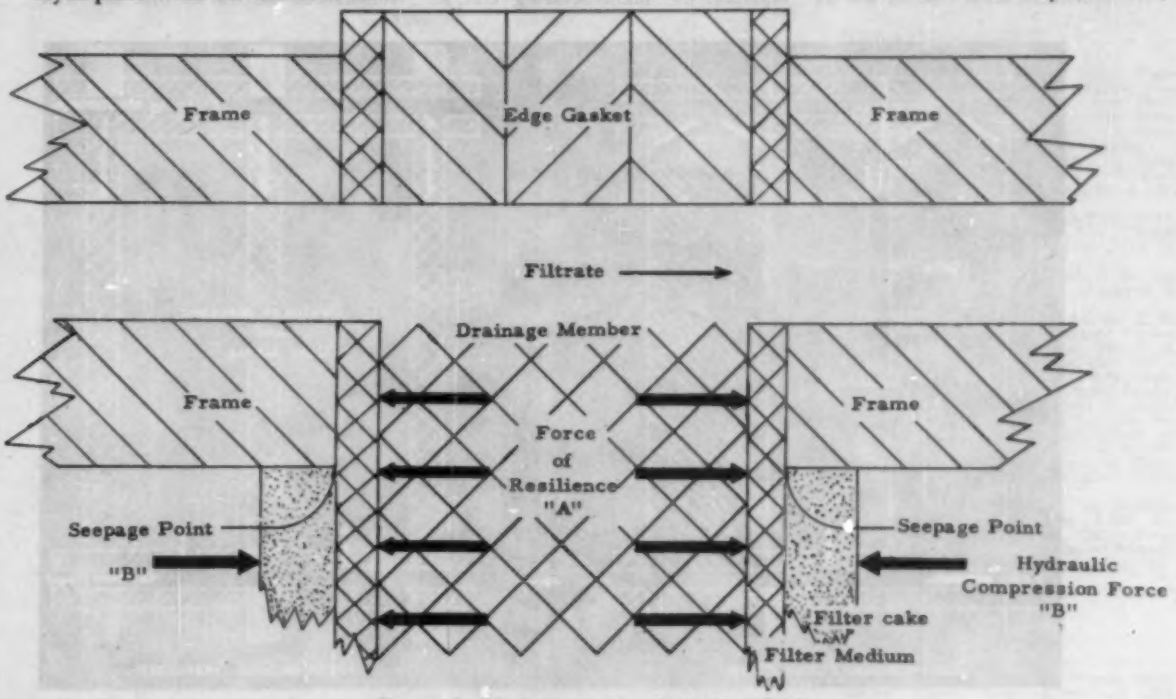

Figure 3. Discharge port gasket action detail.

continued in operation for 100 cycles, a 6-month period. At the end of the period the unit was not self supporting. Operators were required to hold up the filter unit and simultaneously remove the cake.

The basic cause of severe leakage during the initial test with city water was due to permeability at this point outside of the bearing surface before entering the side discharge port; 8.8 psi of back pressure caused copious reverse filtrate flow and severe leakage of city water. It is believed that the leakage could have been prevented by sealing with PVC cement, the inside of the filter media at the point of transport, outside the bearing surface water. The trial unit, which lasted six months, was used without the above localized sealing; depending on viscosity to eliminate leakage.

Assuming that a full press load of filter units would operate as well as the one trial unit described, an economic analysis over a six month period follows.

Special conditions:

Floor space was available only for the one installed 30 in. × 30 in. side feed filter press. Both plate and frame were 1 in. thick. Total plate and frame units, 24. Total space for chambers, 48 in. Filter unit thickness, 0.250 in. Based on 48 in. of available space, 38 unit-and-frame units could be accommodated.

An equivalent labor cost for the 24 cast iron plates vs. 38 Ex. No. 494 filter units is based on an equal time of preparation and process down-time. The actual filter cake removal, cleaning, moving, and filter unit reassemble for the filter unit is less time consuming.

The above economic comparison demonstrates that the manufacturing cost per pound is less for the conventional cast iron plate, and this would be true if another filter press was purchased to obtain the 58% increase in capacity.

If, however, increased capacity was needed, the filter unit Ex. No. 494 method would provide the capacity. A manufacturing cost premium of $0.009/lb. or (in the above comparison) a premium of $2,274 would produce 490,000 lb. over rated capacity The alternative would be to purchase, install, and operate another filter press.

This initial field test was believed to be a success because the unit functioned, and because the economic comparison showed an area where the initial filtration unit would be applicable. The life of filtration unit assembly was double that of the filter media on the conventional filter plate, which demonstrates the severe wearing action of the coarse drainage member.

Based on the foregoing economic comparison, a fourfold increase in filter unit life (two years) would equalize the manufacturing cost/lb. and simultaneously produce 150% of rated capacity for the same equipment cost.

Field trial No. 2

Another field trial was attempted with a chemical manufacturer processing radioactive salts. The filtration equipment was a 36 in. × 36 in. rubber covered, cast iron corner feed-closed discharge (similar to Figure 2) plate and frame filter press.

The operation consisted of a one-hour solids collection period in concentrated HCl, a three-hour concentrated ammonia wash, followed by a four-hour water wash; temperature 70°F, flow rate 0.2 gpm/filter unit.

A three- to four-month period was used to evaluate the filter medium, after which a bonded fabric similar to Dynel-Vinyon, Item 2 of Table 1, was approved. Dynel was selected for the remaining component to accommodate the exposure to alternate acid and alkali environment; edge gasket Item No. 1, Table 2, and drainage member Item 1, Table 3. Two trial filter units, Ex. No. 515, were prepared. The components resembled those in Figue 3.

At the time of trial, the chemical process was producing a filtrate from the regular operation containing a suspension which passed through the regular cloth (a multifilament weave of a polyvinyl chloride fiber) producing turbid filtrate. Under these circumstances the test of this new unit

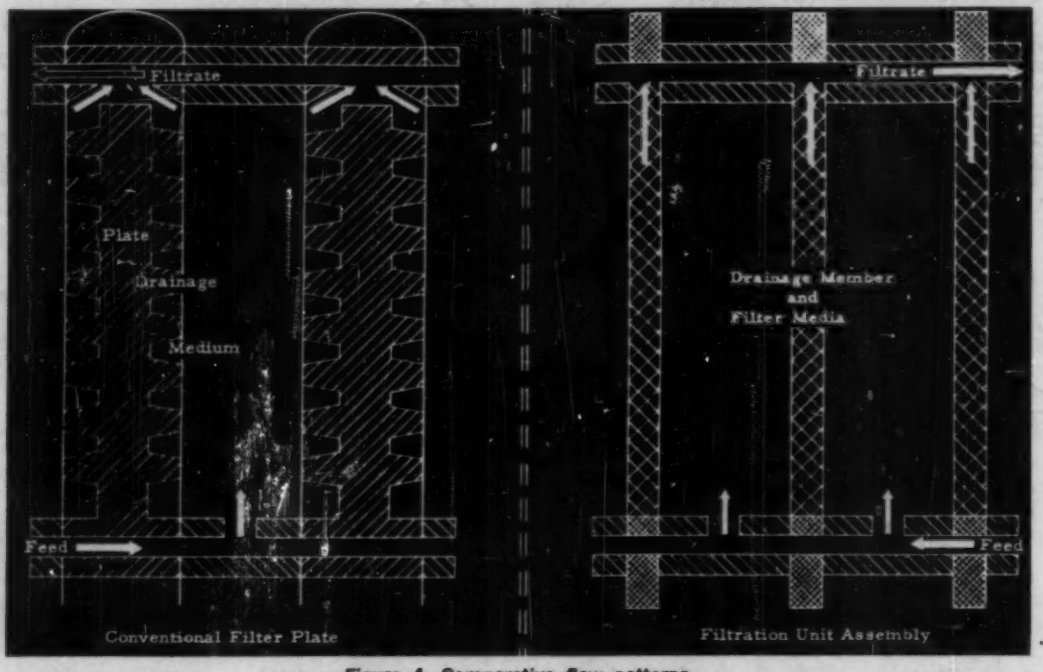

Figure 4. Comparative flow patterns.

was thought to be severe. The two filter unit assemblies were placed adjacent to the inlet and isolated by a blank plate. Since only a turbid filtrate could be obtained after introducing raw liquor at a very slow rate, the test was ended.

On opening the press, the two filter units were distorted 4 in. out of flat (a considerable amount). However, there *was* a clay-like filter cake attached to each surface.

Before repeating the test, the filter units were removed, "hosed off," and scrubbed lightly with a brush. At this point the author inadvertently installed the filter units backwards (easy to do because of their symmetry). The mistake was discovered after the test proved unsuccessful. In the meantime, solids were pumped into the leaves. Again the leaves were removed from the filter press, but evaluation work stopped.

One of the filter units was subsequently cut open for inspection. It was noted that the discharge port bearing surface tended to lose support of the drainage member, no doubt due to the severe distortion encountered.

A few days after the evaluation was concluded, the remaining filter unit (Ex. No. 515) was installed at the opposite end of the filter press, next to the movable head. The filter unit collected a satisfactory cake and continued to do so for four months. Further investigation explained the poor initial trial. The filter frame on the initial unsuccessful test between the two units was restricted. Ex. No. 515, as initially prepared, operated satisfactorily even after pumping solids in the reverse direction.

As a next step, ten more filter units Ex. No. 515 were prepared. All of these functioned but some were tested in other parts of the plant. As a result, about half of this batch continued to function satisfactorily for at least six months. Unlike the Nylon B Filter Unit (Ex. No. 494), it did not soften but retained stiffness throughout its life.

The degree of distortion during operation found in Ex. No. 515 varied from unit to unit; the average amount being an irregular waviness about 1 in. away from the plane. A test series of three filter units was made with a slightly higher tensile strength (80 lb./lineal in. vs. 200 lb./lineal in.) which completely eliminated distortion with no perceptible deviation from the plane. It is believed that complete elimination of distortion will result in greatly extended life by simplifying cake removal, collection, and washing.

An additional phase of testing was completed during this field trial, in which 48 new filter units (Ex. No. 515-B) were prepared. Severe modifications were made, including an attempt to increase drainage-member resilience by the use of PVC sizing. Partial success was obtained in that a full press load operated with a good yield of eight cycles. The PVC sizing reduced the drainage member resilience after repeated use.

At the present state of development Ex. No. 515 would appear to have about the same economic value as Ex. No. 494 presented in Field Trial No. 1.

Table 4.

Equipment Costs	Cast Iron Plate	Ex. No. 494 Filter Unit
Chambers per press	24	38
Price (assume $100 for plates and $75 for Ex. No. 494)	2400.	2850.
Filter Cloth ($10/cloth)		
1st 3 months	240.	..
2nd 3 months	240.	..
	$2880.	$2850.
Labor and Overhead		
Labor/cycle, 4 man-hr. at $2.50/hr.	10.	10.
Labor/100 cycles	1000.	1000.
Overhead/6 months (excluding supplies such as filter cloths) 50% of labor	500.	500.
	1500.	1500.
Production		
Throughput/cycle, gals. of 30% solution	3000.	4750.
Yield/cycle, lb. $Na_2SO_4 + 10H_2O$	8400.	13,300.
Yield/100 cycles, lb. $Na_2SO_4 + 10H_2O$	840,000.	1,330,000.
Manufacturing Cost for 6 Months		
Amortize		
(Filter plate 4% for 6 months)		
(Filter units 100% for 6 months)	96.	2850.
Filter cloths	480.	..
Labor and overhead	1500.	1500.
Total mfg. cost for 6 months	$2076.	$4350.
Cost/lb. $Na_2SO_4 + 10H_2O$	$0.0024	$0.0033

Status of development

The data reported here amounts to an 18-month progress report. Work has been done on the 42 in. × 42 in. filter press with encouraging results. Field trials did not disclose any insoluble problems. Assuming that development work proceeds at its present pace, American Felt Company expects to be in commercial production in the near future.

ACKNOWLEDGMENT

Appreciation is expressed to the American Felt Company for sponsoring the Plate and Frame Filter Unit Project, and for enthusiastic support, initial and sustaining technical assistance given by Mr. Samuel Lamports of the Lamport Company, Cleveland Ohio; who made possible the field trials which indicate that the basic design is sound.

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The belt filter concept

Here's a new technique to solve the problems of medium blinding, poor cake discharge, filtrate blow back, and down time and maintenance costs often encountered in conventional continuous filters.

Since the development of continuous filtration the conventional continuous vacuum drum filter has been foremost in the number of its applications as compared to other available types, primarily because of its greater flexibility and ability to handle difficult-filtering slurries. The basic geometry of the drum filter permits a wide range in the percentage of the cycle time that can be individually devoted to cake formation, cake washing, and cake dewatering, while minimizing inactive time during the cycle. Simultaneously, the conventional drum filter permits discharge of thinner cakes than other types, such as disc, pan, horizontal, or string filters. Finally, the drum filter principle permits a greater degree of self-regulation than other units. When combined with the range in filter cycle time, this allows a wider latitude in productivity per unit area and the facility to handle off-quality feeds.

With the accelerated growth of the process industries, improvements in the methods of continuous filtration were mandatory. Many processes requiring batch or semi-continuous filtration had to be made fully continuous to reduce operating costs.

Greater efficiency in the present methods of continuous filtration is necessary to reduce down time, maintenance and labor costs, improve cake dewatering and washing results, and increase productive capacity.

In the past, modifications of the conventional drum filter have been produced in the attempt to achieve these goals. Thus, continuous filters such as the string and roller discharge type for cake removal and the top feed filter were developed. These modifications, while striking in some instances, still resulted in limited application. To achieve a wider and more economical application, it was felt that a new approach to continuous filtration must be developed. Furthermore, the basic concept must overcome shortcomings and disadvantages in the present design of the conventional drum filter.

Disadvantages of continuous drum filtration

While the conventional drum filter has been more widely applied than

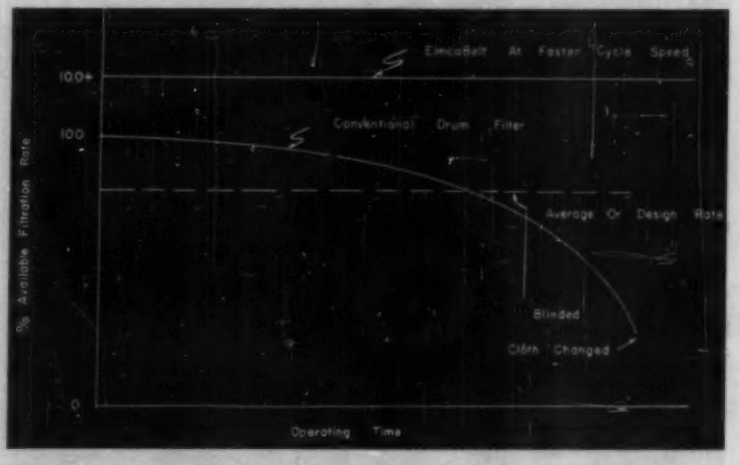


Figure 1. Influence of filter medium blinding on average and instantaneous filtration rates for Eimcobelt and conventional drum filters.

other types of continuous filters, there are still major disadvantages that either prohibit desirable application, or reduce efficiency and increase operating costs. While specific reference is made to the conventional drum filter, these disadvantages are also found in other types. The major disadvantages can be summarized as follows:

Filter medium blinding. A common difficulty is progressive blinding of the filter medium, particularly where extreme fines in suspension, or low solubility salts in solution, are encountered in the feed. In many cases, practically complete blinding may occur in minutes. Where slow blinding occurs (the majority of existing applications today), several days to weeks may elapse before filtration rate is severely reduced, Figure 1. However, this requires a design rate of 70 to 80% of the clean-medium rate to achieve an economic balance between cloth life, operating time, and capital cost. After blinding has progressed to a critical point, the medium must be either replaced or rejuvenated by an acid or alkali scrubbing and rinse.

Blinding generally results from: (1) Plugging of the interstices within the medium by suspended solids in the feed. (2) Chemical precipitation within the filter medium. (3) "Sealing-off" the surface of the filter medium by the shape characteristics of the feed solids.

The air pressure blow-back employed for cake removal on most filters will retard and in many cases prohibit the first phenomenon. However, as the amount of extreme fines and colloidal material increases, the problem is aggravated. Chemical precipitation may be retarded in some instances by blow-back, particularly if atomized steam or water is included in the pressurized air. If not, frequent scrubbing with suitable solvents must be used if the medium is still structurally stable. The third phenomenon is best prevented by a complete cake discharge. But if difficulty is encountered in this operation, blinding will occur rapidly. Furthermore, many times a *skin* of solids left on the medium at discharge is sufficient to initiate accelerated blinding. In such cases, frequent scrubbing with water must be employed. It should also be emphasized that with the many synthetic fibers and multiplicity of weaves available today, all three types of blinding may be reduced, or eliminated by proper cloth searches.

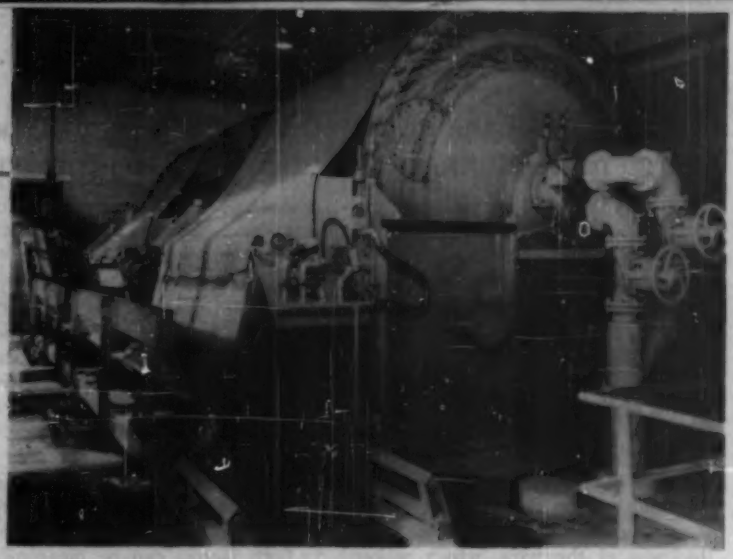


Figure 3. Two 10-ft. diameter by 8-ft. face Eimcobelt filters installed to filter sewage sludge in Spokane, Wash.

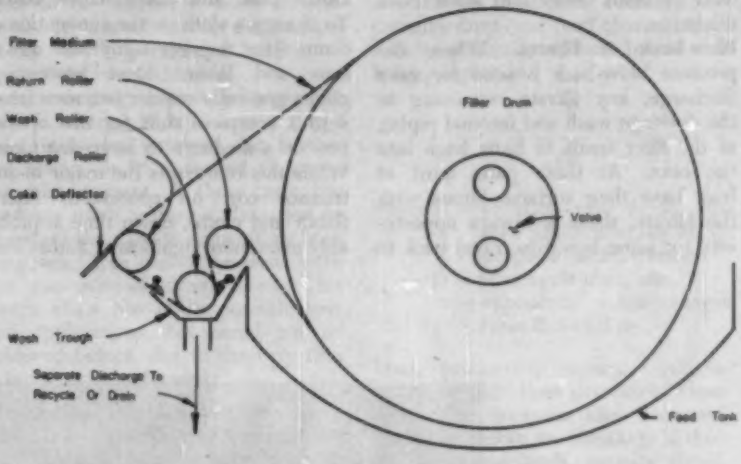


Figure 2. Schematic drawing of the basic principle of the Eimcobelt filter of the type pictured above.

Blinding could be prevented or reduced if a continual or periodic wash of the medium could be employed. However, on the conventional drum filter, this would immediately dilute the feed slurry. Where a periodic wash can be employed, this would mean stopping productive capacity, plus the labor costs for the time required for scrubbing.

Poor cake discharge. As long as a minimum-thickness filter cake of sufficient dryness (approaching residual saturation) is experienced, cake discharge will be practically complete from the conventional drum filter. Generally speaking, ¼-in. minimum thickness is desirable, although values down to ⅛-in. can be discharged as long as it breaks clean from the medium easily. When thin, sticky, or moist cakes are encountered, cake discharge can be severely injured. Also, if multifilament weaves of cotton or other natural fibers must be used, short fibers will be embedded in the filter cake and thereby resist cake removal. The result is a material reduction in filter capacity and simultaneous blinding acceleration.

Incomplete cake discharge is caused

. . . Because of the improved cake removal method, it has been possible to discharge much thinner cakes than with the conventional drum filter.

by inability to set the scraper blade close enough to the media. As the cloth "bellows out" upon blow-back, the scraper must be set far enough away to eliminate excessive wear or tearing of the medium. If the scraper rides too closely, there is danger of smearing the solids onto the cloth, resulting in blinding. If wire winding is employed, the scraper must be set away from the medium at least the thickness of the wire, which makes thin cakes difficult to discharge. If the cake could be made to assume a small radius of curvature different from the medium, the cake would tend to break away and assist cake discharge.

Blow-back of filtrate. When air-pressure blow-back is used for cake discharge, any filtrate remaining in the drainage wash and internal piping of the filter tends to blow back into the cake. As these parts must at least have their surfaces filmed with the filtrate, there is always opportunity for some liquid to travel back to the cake. The string discharge prohibits this phenomenon, but it is limited in application. Furthermore, blow back on the conventional drum filter, or modification thereof, has a dual purpose—cake discharge, and preventing or retarding blinding.

Blow-back of filtrate not only increases moisture content but also "soluble values" in the discharged cake where this factor is important. As both factors can be measured in economic loss or cost increase, it is obvious that prevention of filtrate blow-back is desirable.

Down time and maintenance costs. To change a cloth on the conventional drum filter requires significant down time and labor. Most processing plants generally require two men from ½ to 1 complete shift for this operation on a medium- to large-size filter. While this represents the major maintenance cost on continuous filters (labor and cloth), down time is probably even more significant. Either lost production occurs or large storage capacity must be installed in addition to an oversized filter to provide the necessary production recovery. In some plants, it may even require a spare filter for this purpose alone. To overcome this difficulty, some means must be provided whereby the cloth is not rigidly attached to the drum surface; that a good seal between the medium and the vacuum side be experienced; and that the cloth still be conveniently and rapidly removed and reinstalled.

While all disadvantages have not been cited, these four predominate. Furthermore, if these could be eliminated, most of the minor difficulties would also be solved. With these factors in mind, a basic concept was developed in the EimcoBelt Filter to incorporate the desired features.

Basic concept

The basic principle of the EimcoBelt Flter is shown in Figure 2. Periph-

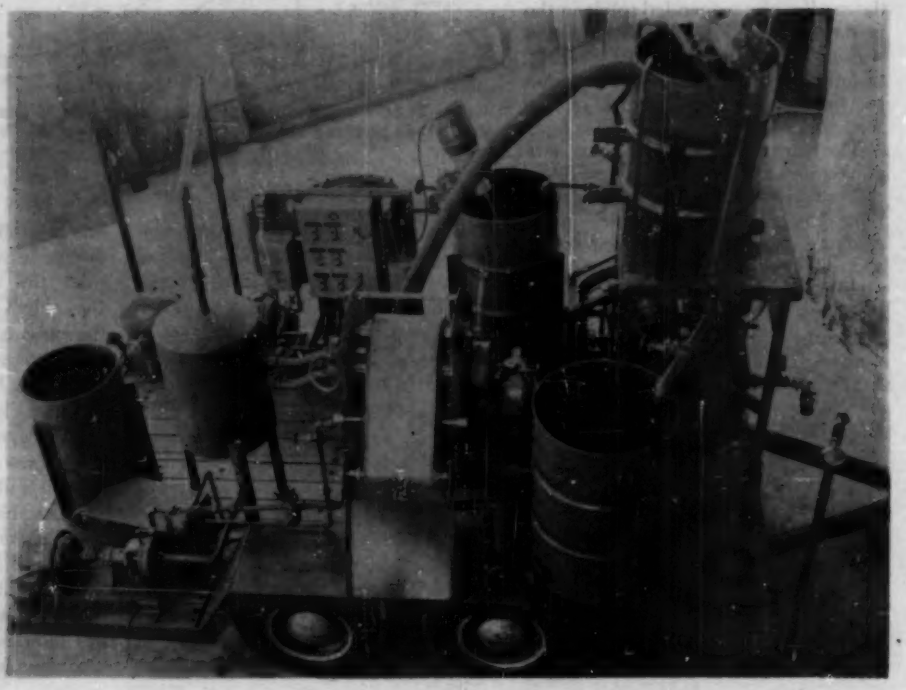


Figure 4. Installed Eimcobelt filter mobile pilot plant, 18-in. diameter by 12-in. face.

ery of each drum section contains a soft rubber or synthetic strip which is slightly raised above the drum surface. The filter medium lays over these strips, sealing the vacuum side from the atmosphere. As the average filter will operate at 20 to 25 in. vacuum, there is about 10 to 12 psi to provide more-than-enough sealing force. The filter medium is an endless belt which travels off the drum to a discharge roll. Cake is discharged at this point and the belt then travels down to a wash roller located in a wash trough which collects the medium wash water. The wash fluid is applied through high pressure sprays to both sides of the cloth. In many installations, to date, only a periodic rinse is required to prevent blinding. In applications where continuous washing must be utilized to prevent rapid blinding, process liquors are usually employed, if the solids are valuable, and then returned to the head end of the flow sheet. The belt passes to a return roller and then back on the drum. For production size units, the percentage inactive time is decreased as diameter is increased.

Alignment of the filter medium is paramount in maintaining good operation. If the medium traveled too far to one side, the drum decking would be exposed, vacuum would be reduced, and the filtrate contaminated by feed slurry. Alignment is achieved by the wash roller, which is split in two halves parallel with the axis. One half is fixed while the other half is movable in either direction parallel with the axis. Sensing microswitches located on both edges of the belt maintain alignment. Alignment is entirely automatic and no operator attention is required.

The four disadvantages have been resolved in the design as follows:

Medium blinding. The ability to wash both sides of the belt permits the removal of solids within and on the surface of the medium. High velocity spray nozzles are employed to allow penetration into the medium. In addition, the belt is passed through three direction changes over small-diameter rolls, which aid in dislodging solids from within the medium. This is illustrated in cases where chemical precipitation occurs in the medium through exposure of the liquid to vacuum and the resulting precipitate is not soluble in water. Chemicals required for cleaning are reduced in the basic design. In addition, the filter may be cleaned in a few minutes, or if very slight contamination of the feed can be tolerated, the filter does not have to be shut down. In the latter case, the chemical rinse is administered either through the washing nozzles or placed in the wash trough for continuous operation. Cake discharge is complete so that only minor amounts of solids remain on the filter medium. Thus, the quantity of solids collected in the belt wash is very small.

Cake discharge. Because the filter medium passes over a small diameter roller, the radius of curvature of the filter cake changes abruptly. This initiates easy discharge. As shown in Figure 3, a sheet discharge will usually result unless the cake has no structural strength, in which case it falls away easily. Because the medium at discharge is always on a constant plane across the face, the cake deflector can be set at a fixed distance. It is not termed a scraper blade, as its purpose is merely to deflect the cake to the discharge point or conveyor. It does not contact the medium unless very thin cakes of 1/16-in. or less are to be discharged.

A secondary advantage regarding cake discharge is experienced if the cake is to be repulped for further processing, or it is desired to pump the cake to waste. In these cases, the medium wash water is also used to sluice off the cake to accomplish both purposes. This cannot be done with the conventional drum filter. This factor alone has made possible several applications that could not be achieved before, due to the very thin cakes that were formed.

Elimination of filtrate blow-back. There is no possible way for filtrate to travel back to the filter cake. Because of the position of the discharge roll in front of the wash trough, no splashing of cloth wash on the filter cake can occur. Thus, minimum cake moisture content and maximum soluble recovery in the filtrate are achieved.

Maintenance and down time reduction. With cloth media, the belt is made endless by a zipper arrangement. When a cloth is to be changed, the zippers are unfastened and the new cloth is zipped to the old cloth. Take-up is provided on the return roller so that the tension can initially be released and properly applied when the new cloth is in place. The entire operation will take one man about 15 to 30 min. on the largest unit built.

Filter medium costs are generally a major item of maintenance. Cloth life on similar installations has always been increased at least 50%, and as much as 300%, compared to the conventional drum filter. This is due to the even tension on the cloth, lack of contact with the scraper blade, and elimination of caulking or wire winding. It should be emphasized that the moving parts and bearings on all rollers are completely protected from the liquids and solids. All alignment mechanism and shaft bearings are outside the side panels on the wash trough. The internal bearing on the alignment roller is protected by a flexible rubber or synthetic sleeve.

Because of the improved cake removal method, it has been possible to discharge much thinner cakes than with the conventional drum filter. Cakes as thin as 1/32 in. have been completely discharged and it has always been possible to design on at least a minimum thickness of ⅛ in.

Productive capacity per unit area of the filter at constant submergence, pressure drop, and feed characteristics can be generally defined by the following equation:

$$R = \frac{K}{\Theta^x} \qquad (1)$$

where R = filtration rate in lb. dry cake solids/hour/sq. ft.
K = proportionality constant
Θ = filter cycle time, min.
x = exponent, value ranges from 0.5 to 1.0

Thus, productive capacity will increase as cycle time decreases. However, cake thickness also decreases. Thus the ability to discharge a thinner cake completely permits significantly higher design and operating capacities per unit area.

Other advantages of the filter design can also be cited. The drainage section of the drum is completely exposed between the take-off and return point of the belt. Thus, this area is easily cleaned if special sanitation measures are required. If a cloth should be torn, it can be easily sewn or repaired due to the access to both sides of the medium. The cloth can be saved and the repaired spot will still maintain its filtering surface. Vacuum levels comparable with the conventional drum filter on any application can be realized at the same vacuum pump capacity due to the good seal between medium and the drum. Thus, filtration rate is maximized and cake moisture content minimized.

The filter has also been developed to employ a metallic belt made of a

. . . Economic savings were also large . . . due to improved operation, reduced labor and maintenance costs, less downtime and cloth consumption, increased efficiency.

special spiral and rod weave such that each rod acts as a hinge. There is no flexing of the metal in passing over the rolls to cause metal fatigue. The metal belt is constructed of stainless steel or other metals resistant to the application involved. It is designated a permanent medium, as life is measured in terms of several years. Due to its open nature, it is applied to either coarse, fibrous, or highly flocculated solids. It has been widely employed on sewage sludges where filtrate clarities of 100 to 500 p.p.m. suspended solids are achieved.

Development program

The basic concept was first tested at Michigan State University on a joint project in the Sanitary Engineering Department, partially sponsored by The Eimco Corporation. Test work was conducted on a 4 ft.-diam. × 2 ft.-face unit. Following this, a trailer-mounted unit was constructed employing an 18 in. diam. × 12 in.-face unit. As shown in Fig. 4, the trailer unit was complete with a vacuum pump, filtrate receiver and pump, chemical mix tanks, feed tanks, starter panel, etc. Thus, the unit could be easily moved to a plant. All that was required was a power source, seal water for the vacuum pump, and a filter feed line to the trailer. The mobile pilot unit was taken to all areas of the United States and Canada and visited over sixty plants. This work permitted observation of the efficiency of the concept on a wide variety of filter feeds.

Because of the excellent results obtained, full scale installations were made to complete the development and design of the alignment principle. In several instances, installations were made where conventional drum filters were already employed so that direct comparison could be made. Following completion of the full scale work, installations were made on operations which had never been successfully achieved by other types of continuous filters. Some examples follow.

Filtration of metallurgy liquors

In a large Western cobalt-nickel-copper chemical extractive metallurgy plant an acid, pressure, temperature leach is employed. The leach liquors containing the valuable metals in solution must be separated from the gangue solids. The leached pulp is adjusted for pH by limestone, resulting in a residue primarily of gypsum. The pulp is then filtered on two stages of conventional drum filters with cake washing, the filtrate going on to further purification and recovery of copper. After elimination of copper, lime is added to complete purification, prior to electrolysis for cobalt recovery. Following lime addition, the slurry is clarified in a thickener, the overflow going to the electrolytic plant. The thickener underflow passes to two stages of conventional drum filtration for soluble metal recovery, the filtrate returning to the thickener.

Difficult filtration problems were encountered due to severe blinding. Many times filtration was stopped completely and the filters had to be continually shut down for scrubbing of the medium—sometimes after only a few revolutions of the drums. The filters in the final purification circuit also caused severe problems with the preceding thickener. The emergency overflow from the filter was drained to the thickener feed. As cloth blinding proceeded, filter feed slurry overflowed back to the thickener severely injuring the thickener overflow clarity. This, in turn, upset electrolytic refinery operations.

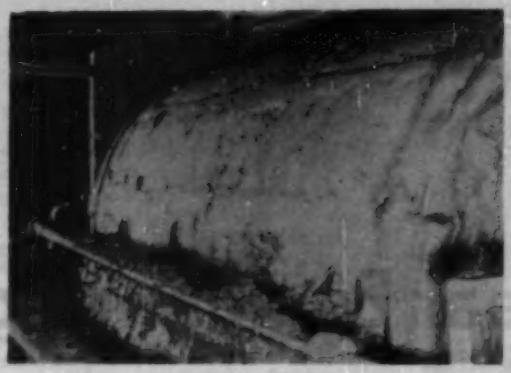
The initial cloth EimcoBelt was installed on the first-stage filter following the thickener underflow. After installation filter-medium blinding was immediately eliminated. Figure 5 is a photograph of the conventional drum filter showing the extreme blinded condition of the 6 ft.-diam. by 6 ft.-face unit. The even cake thickness of the EimcoBelt Filter is apparent, indicating the non-blinded condition of the cloth. Operation improved such that the filter was always able to stay ahead of the thickener, further improving operation in the electrolytic refinery. In addition, the following filter stage became unnecessary and was shut down.

Of primary importance was cobalt recovery. Total recovery for this purification portion of the flow sheet had averaged 93%. With only the single-stage EimcoBelt in operation, recovery increased to 97%. Table 1 is a summary of increased product recovery values. It will be noted that the 365-day/yr. basis increased product recovery value by over $223,000. A second unit was installed on first stage filtration of leached pulp. Filter size in both cases was 4 ft-diam. by 8 ft.-face. Similar results were again experienced. Blinding was eliminated and filtration rate markedly improved. Cobalt recovery for this portion of the circuit had averaged 91%. After installation, total recovery increased to 95.5%. On an annual basis, this amounted to over $358,000 in extra product recovery value, Table 1.

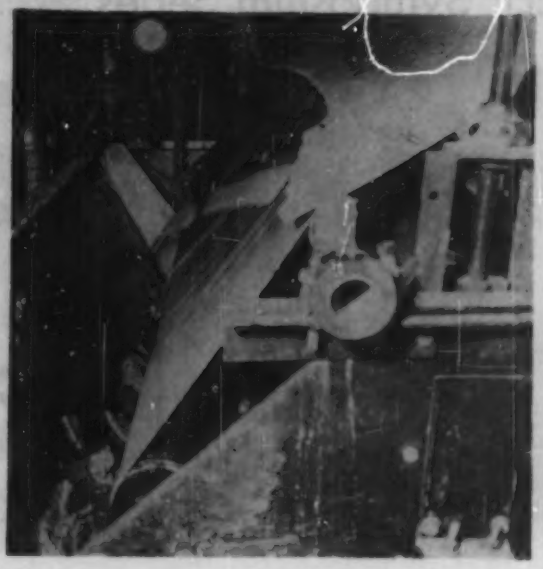
Table 1. Cobalt recovery increase in chemical extractive metallurgy plant EimcoBelt and conventional drum filtration.

Cobalt Liquor Purification Plant	
Total cobalt recovery (two-stage conventional drum)	93%
Total cobalt recovery (single-stage EimcoBelt)	97%
Extra cobalt recovery by EimcoBelt	350 lb./day
Daily extra recovery product value @ $1.75/lb.	$612.50/day
Annual extra recovery product value @ 365 day/yr.	$223,562.50/yr.
Leach Plant	
Total cobalt recovery (two-stage drum)	91%
Total cobalt recovery (first-stage EimcoBelt, second-stage drum filtration)	95.5%
Extra cobalt recovered by EimcoBelt	560 lb./day
Daily extra recovery product value @ $1.75/lb.	$980.00/day
Annual extra recovery product value @ 365 day/yr.	$358,700.00/yr.
Total extra recovery product value	$582,262.50/yr.

Figure 5. Comparison of blinded and non-blinded filters.



Partially blinded conventional drum filter.



Non-blinded Eimcobelt filter.

It is apparent that blinding of the filter medium results in poor cake washing and reduced filtration rate due to uneven penetration of the wash fluid through the filter cake. Near the blinded spots, wash fluid passes through the cake at a much slower rate, as pressure drop occurs primarily over the blinding solids. Thus, "islands" of improperly washed cake appear, increasing soluble losses. With a non-blinded medium, an even, homogeneous cake is formed which permits consistent passage of wash fluid through all portions of the cake. Economic savings were also large on this installation due to improved operation, reduced labor and maintenance costs, down time and cloth consumption, and increased efficiency in the electrolytic refinery. However, by far the most striking factor is the more-than $582,000 annual increase in final product. This can be attributed primarily to the maintenance of the non-blinding medium and elimination of blow back.

Dewatering of gluten and fine fiber

In a wet corn milling plant in the Middle West, after steeping in SO_2 liquor, the corn kernels are coarse-ground to free the oil bearing germ. Following germ separation, fine-grinding frees starch and gluten from the fine fibers and coarse bran fibers. The latter are screened off as coarse fiber, the underflow passing to Grits screens. This screen overflow contains the fine fiber together with some gluten. As such, it is difficult to dewater and has necessitated filtering on plate and frame presses where filtration rates are low, labor costs high, and the filter cloths must be washed after every batch.

Two 10 ft.-diam. by 10 ft.-face EimcoBelt Filters were installed to dewater the Grits in place of the plate and frame presses. Stainless steel permanent medium, discussed earlier, was employed on the units due to the fibrous nature of some of the feed solids. The belts had to be washed continuously or blinding would have occurred in a few revolutions of the drum. However, process liquor is employed so no solids are lost and the plant water balance is not altered. The plant operates six days a week, 24-hr./day. In the plate and frame press cloths have to be washed every batch, indicating the blinding nature of the solids. The EimcoBelt is resistant to the blinding action. The belt is steam cleaned only once or twice a week.

The plant has been in operation for some time so that direct economic comparison can be made between the batch filtration and continuous filtration methods, Table 2. It will be noted that partial savings for the EimcoBelts are $36,650/yr. Of equal importance is the fact that 9.3% of the installed filtration area is required as compared with the plate and frame units. Other advantages are improved sanitation and a continuous flow of consistent moisture-content solids to the dryers. The somewhat higher moisture content of the EimcoBelts is offset by the greater dryer efficiency. The continuous filters are also self operating, require little operator attention, and no supervision.

Table 2. Economic and operating comparison filtration of corn grits.

	EimcoBelt	Plate and Frame
Filtration Rate		
Lb. dry solids/hr./sq. ft.	5.7	0.5
Gal. filtrate/hr./sq. ft.	8.7	0.9
Labor requirements/shift, men	0.5	2.0
Required filtration area, sq. ft.	628	6750
Labor costs/yr.	$10,500	$42,000
Power costs/yr.	$600.00	$1750.00
Excess filter cloth cost for plate and frame filters over maintenance costs of EimcoBelts/yr.	..	$4000.00
Partial savings/yr.	$36,650	

What's in
Vol. 55, 1959
No. 23, Part VI
(continued)
No. 27, Part VII

Nuclear Engineering

Two-phase steam-water pressure drops, H. S. Isbin, R. H. Moen, R. O. Wickey, D. R. Mosher and H. C. Larson.
Frictional pressure drops for steam-water mixtures have been determined for the following ranges of conditions: pressure, 25 to 1,415 lb./sq. in. abs; total flow rate, 454 to 4,350 lb./hr.; and quality from about 0.008 to 0.98. The steam-water mixtures were synthesized by mixing steam and water, and pressure drops were measured for adiabatic flow in horizontal pipes 0.484 and 1.062-in. I.D. The data are compared to standard correlations, and a new restricted correlation is suggested which takes into account the pressure and flow-rate dependencies.

Free-convection heat transfer to water and mercury in an enclosed cylindrical tube, J. P. Hartnett, W. E. Welsh, Jr., and F. W. Larsen.
Local free-convection heat transfer results are reported for water and mercury with uniform heat flux. The system was found to be inherently quasi-steady with the temperature oscillations more pronounced with mercury as the working fluid.

Experimental data were also obtained with the tube inclined 30 deg. from the vertical, and the resulting heat transfer performance was found to be significantly increased.

Auxiliary equipment for radiochemical processing, W. E. Unger.
Most radiochemical processing equipment is basically similar to industrial counterparts. The principal distinguishing differences are details of design, the quality standards to which radiochemical equipment is fabricated, and the massive shielding peculiar to the latter.

Examples of both specially designed items, and the adaptation of commercial equipment, including valves, filters, centrifuges, samplers, and carrier-chargers, are described.

Flow generation, measurement, and control, J. Dunn and H. M. Jones.
The design criteria for equipment in a remotely operated aqueous separations plant are presented.

Improved materials of construction, seal design, and methods of remote replacement have made it possible to adapt submerged regenerative and deep-well turbine pumps, driven by motors located above and sealed from the tanks, to chemical-separations service.

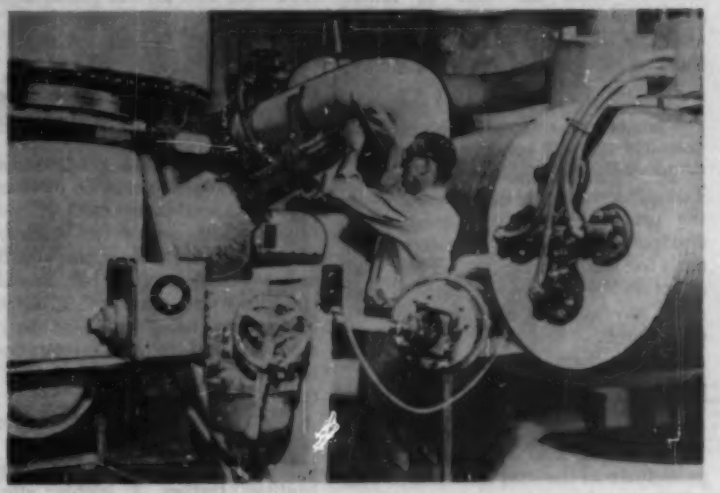
Description of a typical flow-system installation is presented, together with a detailed description of the rotameter-transmitter, amplifier-converter, recorder-controller, and control valve.

Treatment of radioactive wastes with ion transfer membranes: removal of bulk electrolytes, E. A. Mason, E. J. Parsi and A. J. Giuffrida.
Use of anion transfer membranes in electrolytic cells was investigated as a means of removing and separating bulk electrolytes from cationic fission products. Nitric acid and aluminum nitrate were used as typical electrolytes, and sodium was used as a tracer representing cationic species. Deacidification of nitric acid and precipitation of hydrous aluminum oxide in granular form were accomplished.

The mechanism of deacidification, effect of operating variables, and stability of membranes to chemical and radiation attack are discussed. A brief cost estimate is included.

A digital program to evaluate transients for nuclear power plant design, F. J. Scheib and A. J. Arker.
The design limitations of a nuclear power plant for mobile use often depend on the transients which the plant undergoes during normal or casualty operation. Examples of decisions which depend on transient evaluation in the design of a pressurized-water plant are given, and the model digital computer program used to analyze such transients is described. Important features of this program are nonsymmetrical and variable flow operation of the two coolant loops, use of nonanalytic input data, and flexibility for alteration.

Control of the PRTR—A gas-balance method with supplementary mechanical shims, J. F. Fletcher.
The Plutonium Recycle Program, a comprehensive research and development program, has as its goal the development of safe, economical methods of using plutonium fuels in power reactors.



The Plutonium Recycle Test Reactor is a test facility essential to this program and designed to have a high degree of versatility and to be capable of operating under a great variety of experimental conditions. The control system used provides an unusual degree of reactor safety.

A study of the feasibility of a tracer system for locating a fuel-element failure in a Pressurized Water Reactor, Meyer Pobereskin Duane N. Sunderman, Aaron Eldridge, George D. Calkins and Walston Chubb.
This investigation indicated that a system of tracer elements for location of fuel-element failure merited development. The method consists in adding small amounts of different pairs of elements to the fuel alloy of each subassembly. When a fuel-element failure occurs, a portion of the coolant is analyzed radiochemically for the elements added to the fuel as tracers. The radioactive species of the elements detected indicate the subassembly in which the failure has occurred.

Eleven elements were found to be suitable tracers.

Coolant temperature rise in a Pressurized Water Reactor during a loss of flow incident, Joel Weisman, Shepard Bartnoff and G. C. Tirellis.
A method is described for calculating the coolant temperature at the reactor outlet as a function of time following a loss of pumping power and the consequent loss of coolant flow. The effects of negative temperature coefficient and delayed gamma radiation on the heat production rate of the reactor are considered and contributions to the total coolant temperature rise calculated from both the nucleate boiling region and the nonnucleate boiling region of the core.

Reprocessing costs for fuel from a single-region Aqueous Homogeneous Reactor, A. C. Jealous and R. J. Klotzbach.
The cost is estimated for a fuel-reprocessing plant to recover fissionable, fertile, and moderator materials from irradiated slurry fuel of the Pennsylvania Advanced Reactor (PAR). The estimate is based on a reprocessing plant designed to process 47 kg. of thorium/day for return to the reactor plant.

Off-site solvent-extraction decontamination of PAR fuel in AEC multipurpose plant would cost more than complete-on-site reprocessing.

Pilot plant fluorination of uranium fuel elements by bromine trifluoride, Gerald Strickland, F. L. Horn and Richard Johnson.
The dissolution of uranium in bromine trifluoride at 250°F was investigated in continuous equipment on a pilot plant scale. In particular the autocatalytic effect of the UF_6 concentration on the dissolution time of unirradiated B.N.L. reactor slugs was determined. A series of nine runs is described in which the UF_6 concentration progressed from 0 to 4.5 mole %.

Vol. 55, Nos. 23 & 27, are available at $3.50 each to members, $4.50 to nonmembers.

Reprocessing uranium-zirconium-alloy reactor fuel elements, C. B. Leek, R. B. Lemon and F. K. Wrigley.
The process employed for the recovery of uranium from uranium-zirconium alloy reactor fuel elements at the Atomic Energy Commission's Idaho chemical processing plant is described, and the results of the initial processing and decontamination operations are summarized.

Effect of geometrical shape on the continuous dissolution of aluminum in mercury-catalyzed nitric acid, A. F. Boeglin and J. A. Buckham.
The results of a study of the effect of geometrical shape of aluminum-reactor fuel elements on the dissolution rate in mercury-catalyzed nitric acid are presented. Statistical analysis of the data showed that the main effects, feed rates, catalyst concentration, and shape, and all first-order interaction effects had a significant effect on dissolution rate. A mathematical relationship between dissolution rate and feed rate, catalyst concentration and the catalyst concentration by feed-rate interaction, was graphically developed for each shape.

General economics of chemical reprocessing using solvent extraction processing, F. L. Culler, Jr.
The competitive requirement of producing electricity at 8 mills/kw.-hr. in the United States places limitations on the over-all recycle costs of irradiated fuel and fertile material.

Based on buy-back prices published by the AEC the residual value of fissionable and fertile material in irradiated fuel is almost always greater than the cost of recycle. Reprocessing probably will always be required.

No. 27, Part VII

Radiochemical research in the U.S.S.R., Victor Spitsyn.
A survey of the state of the art in the

U.S.S.R. from the time of initial studies of radioactive elements soon after the discovery of radioactivity to the present (date of article is 1958).

The use of tracer atoms in the physicochemical study of some inorganic polycompounds, Victor Spitsyn.

Tracer atoms were used to ascertain the primary stages of formation of aquopoly and heteropoly compounds, and to study their properties and structure by isotopic exchange, and other physical and chemical methods of research.

It has been suggested that the process of formation of aquopoly and heteropoly compounds is related to the appearance of hydrogen bonds between the anions of acids which participate in the said interaction. The existence of oxonium groups in the structure of aquopoly anions may also be assumed.

Effect of gamma radiation intensity on the polymerization of ethylene, B. G. Bray, R. A. Carstens, O. A. Larson, J. J. Martin and K. K. G. Sikchi.

In the field of photochemical reactions it is suggested that the reaction-rate constant often varies as the square root of the intensity of the radiation field. For the two-step mechanism proposed in this study it was found that the initiating reaction constant was directly proportional to the intensity of radiation. A secondary reaction constant was found.

Blast effects tests of a one-quarter-scale model of the air force nuclear engineering test reactor, Wilfred E. Baker.

The results of a series of nuclear accidents to a one-quarter scale model reactor simulated by explosives and propellants are presented. The accuracy of simulation of these power excursions and the applicability of laws of scaling, blast loading, and corresponding transient structural response are discussed.

Heavy-water reactors for power production, David P. Herron.

From a nuclear standpoint, heavy water is the most attractive moderator for thermal reactors because its high moderating ratio permits excellent fuel economy. The principal factors affecting the fuel-cycle and capital in design of heavy-water reactors are reviewed, and several possibilities for reducing the power cost of this type of reactor are discussed.

Conversion of uranium hexafluoride to uranium tetrafluoride, S. H. Smiley and D. C. Brater.

The atomic energy program has a need for large quantities of uranium metal and uranium salts of various uranium-235 assays for nuclear reactors. Since enriched uranium is usually available as the hexafluoride, it is necessary to convert this compound to uranium tetrafluoride as an intermediate step in the preparation of most of the desired reactor fuel materials.

Contrary to published literature the single-step reduction of UF_6 to UF_4 with hydrogen was found to be quantitative; further a highly efficient, safe, economical, continuous method was developed and adapted for large-scale production use.

High-temperature processing of molten fluoride nuclear reactor fuels, Warren R. Grimes, James H. Shaffer, Newman V. Smith, Richard A. Strehlow, Wilfred T. Ward and George M. Watson.

The removal of certain undesirable fission-product fluorides from reactor fuels consisting of molten mixtures of uranium tetrafluoride with other fluorides has been successfully accomplished in small-scale experiments by precipitation techniques which may be adaptable to large-scale application. Data relating to the solubility of xenon and other rare gases are presented and are pertinent to the ease of removal of such gaseous fission-product poisons.

Summary report: Economic comparison of Zircaloy and stainless steel in nuclear power reactors, Manson Benedict.

In most nuclear reactors being designed for commercial power production, it is technically feasible to use either stainless steel, zirconium, or one of its alloys as structural material, fuel cladding, or fuel diluent. When zirconium is used within the neutron flux of the reactor, its low neutron-absorption cross section gives zirconium an important economic advantage over stainless steel. On the other hand, zirconium and its alloys cost more.

This study was made to assist reactor designers in determining when it is advantageous to consider zirconium.

Boiling-heavy-water reactor for process steam and power, Patrick J. Selak and George B. Humphreys.

For a hypothetical reactor plant located in the United States there is no significant difference in the net fuel cycle cost or the cost of steam produced, whether the reactor is operated with fuel element reprocessing or on a throw-away basis. This suggests the suitability of this reactor for remote mining and processing operations.

Laboratory facilities for nuclear engineering education at MIT, T. J. Thompson.

A comprehensive program of graduate study in nuclear engineering is intended primarily for students with undergraduate degrees in physics, chemistry, or metallurgy or chemical, civil, electrical, or mechanical engineering. For those interested in specializing in nuclear engineering, the program leads to the degree of M.S. in nuclear engineering or Sc.D.

Courses taught are outlined.

Conceptual design of pyrometallurgical reprocessing plant, Louis Besel and Joseph Koslov.

A pyrometallurgical reprocessing plant for handling fuel from a 500-Mw. fast-breeder reactor is described. Also included are capital and operating costs and a discussion of problems requiring further investigation.

The Nitrophos extraction process for the separation of zirconium and hafnium, Wayne H. Keller and Irwin S. Zonis.

The several possible systems for separating Zr and Hf are reviewed briefly. The reasons for selecting the Nitrophos liquid-liquid extraction process are discussed. The laboratory and pilot plant experiments are described and the data presented. Under the conditions studied, reactor-grade zirconium can be prepared in a column with less than ten theoretical stages. The commercial plant design is described and preliminary operating results are given.

Natural-circulation boiling reactor with tapered coolant channels, S. G. Bankoff.

It is suggested that some of the heat transfer characteristics of natural-circulation boiling reactors might be improved by employing tapered coolant channels.

A previously developed flow model

for straight channels is used to predict frictional losses in tapered channels with uniform and with cosine heat-flux distributions.

Temperature rise in underground storage sites for radioactive wastes, R. S. Schechter and E. F. Gloyna.

An attempt is made to determine the limits of the temperature increase resulting from the release of energy by high-level radioactive wastes stored in underground spherical cavities. This determination is accomplished by calculating the temperature rise—on the basis of two models, one fixing the upper limit of temperature increase and the other the lower limit.

The results of these calculations are presented in a generalized graphical form to facilitate design calculations.

A technical and economic analysis of the separation of plutonium and fission products from irradiated nuclear reactor fuels, H. A. Ohlgren, J. G. Lewis, M. E. Weech and G. W. Wensch.

The technical background for chemical processing of irradiated nuclear reactor fuels is discussed, and aqueous solvent extraction methods for the separation of uranium from plutonium and fission products are briefly described.

Estimated capital and operating costs are presented for an aqueous separation of plutonium and fission products from irradiated fuel elements of a fast-breeder power reactor.

Abstracts of other current volumes in CEP's Symposium Series will appear in subsequent issues of the magazine.

PROCESS

DUNCAN L. KING
San Francisco Chemical Company
Montpelier, Idaho

Calcining phosphate rock

Fluid suspension technique permits full instrumentation and control of conversion reactions

IN THE LATE FORTIES and early fifties, the metallurgical field became interested in FluoSolids reactors as a means of holding solids in fluid suspension for various reactions involving heat, atmosphere, and detention. The first and most obvious thermal reaction to which the "solids" principle was applied was the calcination of exothermic sulfide ores. Many of the early reactors were installed for the purpose of *roasting* sulfide concentrates prior to cyanidization or other leaching treatments.

The next important installations, notably in South Africa, came as the result of the uranium industry and its concomitant requirement for sulfuric acid. As the equipment has become better understood, it has been used for a variety of purposes, from drying coal, to burning limestone into quicklime. Up to the work presented in this paper, the equipment has never been commercially used in calcining phosphate rock. In fact the potential uses of this versatile principle have hardly been scratched. The FluoSolids calcination is not simply a substitute for the old tray roasters or cylindrical kilns, rather it is a system whereby material can be kept in suspension, virtually free of contact and under any atmosphere desired. The application of the system to phosphate rock, and particularly, to Western phosphate rock has many novel and interesting aspects. In this article, which is intended to be a nontechnical discussion of the facts responsible for the selection of this equipment over the more conventional tray or kiln-type roasting machines, it is first necessary to describe certain of the physical characteristics of Western phosphate rock.

Simply stated, unweathered Western phosphate rock is a dark brown to jet black, fetid, *oil shale*. In its miogenetic state it contains from 2 to 4% carbon. This carbon is in the form of distillable hydrocarbons (up to 28 gal./ton). In an atmosphere of free oxygen the thermal curve runs a normal line until approximately 610°F is reached, near which point the hydrocarbons ignite and the mass (if uncontrolled) exothermically attains 1950 to 2000°F. This characteristic, under the controlled conditions in the reactor, gives the operation a "free fuel ride" to the full hydrocarbon content of the rock.

During an 18-month run in a two-hearth, 48-in. diam. reactor (capacity 50 ton/day calcines) several of the various Western phosphate rock types tested contained sufficient fuel value

Phosphate rock

continued

to maintain calcining temperatures for a full hour residence in the calcining hearth without the addition of outside (or supporting) fuel. In one rock type tested it was actually necessary to set up flow-rate controlled water guns to hold the upper (preheat) hearth temperatures down below the combustion point.

Western phosphate rock is a marine sediment consisting of high grade, oölitic (or spherulitic) granules, cemented together with relatively low grade phosphosilicates and phosphocarbonates. Reducing this material, first by crushing, then by impaction —and, under circumstances of finer grinding, finally by rod-milling—always results in a difference in P_2O_5 values between the fine and the coarse; the fine (—250 mesh) being largely made up of the friable, low grade cementing material, and the coarse (+250 mesh) being the oölitic and more resistant high grade fraction. This characteristic has long been advantageously used in "upgrading" Western phosphate rock (by classification and rejection of the —250 mesh "low grade").

By using fluidized reactors as the calcining system this dressing of Western phosphate rock is accomplished. The material is held in suspension over the various hearths by a stream of air, having sufficient "space rate" to keep the coarsest or heaviest particles in dynamic suspension. Thus each hearth, windbox and freeboard becomes a hindered-settling classifier, and the primary and secondary (or "hot" and "cold") cyclone systems become material traps for (1) "below grade" and (2) "low grade" fractions of the feed.

In a fully integrated system this classification feature will discharge from the vortices an air-swept intermediate material that will be the subject of further concentration by known methods; resulting in a "tailing" and a salable concentrate. Further, by the sweeping-out of the intermediate material, it will "upgrade" the coarse calcines, by taking from them these lower-grade fractions.

As the hydrocarbon content of Western phosphate rock dilutes the material, it is obvious that burning it out "up-grades" the resulting calcines by the percent LOI (loss on ignition) contained in the feed. In addition to the hydrocarbons, the rock contains some water of crystallization which is driven off at calcining temperatures —from 1400 to 1600°F.

In every case, with the exception of pulverized rock used as a direct application material, all phosphate rock produced in the world is a basic material feed for some type of subsequent treatment, principally some form of acidulation. The chemical make-up of the material, therefore, is of prime importance, particularly since phosphate rock is an exceedingly low-priced material, f.o.b. mines. Freight, acid, and plant process costs are normally many times the f.o.b-mines cost of the rock. It is of the utmost importance, therefore, that the chemical quality of the material be made as high as possible.

Any conversion practiced on the rock must be to the benefit of grade (cheaper freight per unit P_2O_5 delivered at the processing plant) and should result in a conversion product that saves processing costs—(1) lower acid requirement, (2) better acidulation characteristics, hence higher plant throughput.

Prior to the use of FluoSolids conversion, and with one notable exception, the calcining of phosphate rock has been practiced only on rock containing objectionable quantities of hydrocarbons. These instances have been to burn out the hydrocarbons to make a compatible gypsum crystal in phosphoric acid manufacture. The exception was a German account—using a nitric acid acidulation process and calcining Moroccan rock in conventional kilns at Khouribga.

Since it is almost impossible to create control conditions in tube kilns and tray roasters, all former calcining treatments have had to maintain the simple objective of burning out the LOI, without an opportunity of controlling the other conversion reactions. Also in these instances, particularly in tray roasting) it will be found that, to maintain an "average temperature" at any given value, it has been necessary to *overburn* parts of the feed, while underburning others. It has been, then, impossible to create and hold conditions that could do more than accomplish the simple burning of the carbonaceous feed into a fairly carbon-free calcine.

Tray roasters in calcining use offer little or no control. Fluidized reactors, by contrast, have ample opportunity for full instrumentation and control of:

1. Feed and discharge.
2. Bed level, or detention depth.
3. Near perfect temperature conditions of each bed, throughout its entire area.
4. Atmosphere of all zones.
5. Space-rate changes to accomodate changes in feed size or the size of the material reporting to the cyclone systems.

This gives the operator practically unlimited opportunity to not only effect calcination in its simplest sense, but also to induce in the conversion products the most favorable material desired for each particular end use, or process requirement. It is the first system to be offered that makes possible an inexpensive means of producing from natural phosphate rock, a near-optimum raw material for subsequent processing.

Acidulation techniques have been developed which will produce acceptable results on natural rock or concentrates available from the nearest field of supply. These have been concerned, in all cases, with natural (unconverted) rock or concentrates, hence, there has been little or no occasion to develop more than a "satisfactory treatment," flexible enough to withstand the broad range of feed accompanying a product of nature. Most of these changes, particularly, in Western rock are caused by greater or lesser weathering of the acid grade beds. Calcination is indicated (from a standpoint of contained carbon) only on the unweathered and relatively deep-seated of the mined rock. Therefore, it follows that the constancy of the material to be calcined will be much greater. The conversion products, meanwhile, rather than being the effect of rapidly changing weathering zones, will be closely controlled, within an enclosed vessel, and within, say, an hour's residence.

It is more than posible, then, that when this material is available to the industry, techniques will be developed that can have a far-reaching effect on production costs.

This paper has been concerned principally with the use of the fluidized system as a better and more closely controlled principle for converting highly carbonaceous phosphate rock into a more compatible calcine. While this *is* the prime, (and certainly the immediate) purpose of the commercial installation now under construction, it should be pointed out that the production of a more satisfactory calcine is not the limit of this equipment respecting thermal conversion of Western phosphate rock. Research is under way which is expected to carry the conversion considerably beyond simple, controlled calcination.

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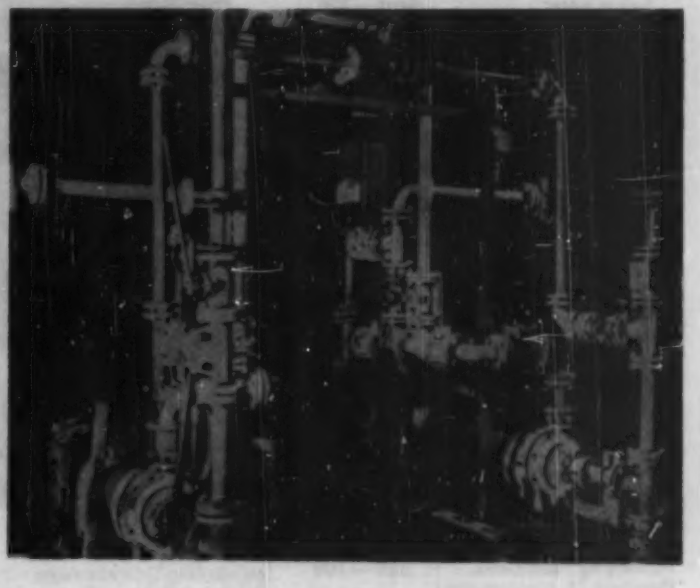

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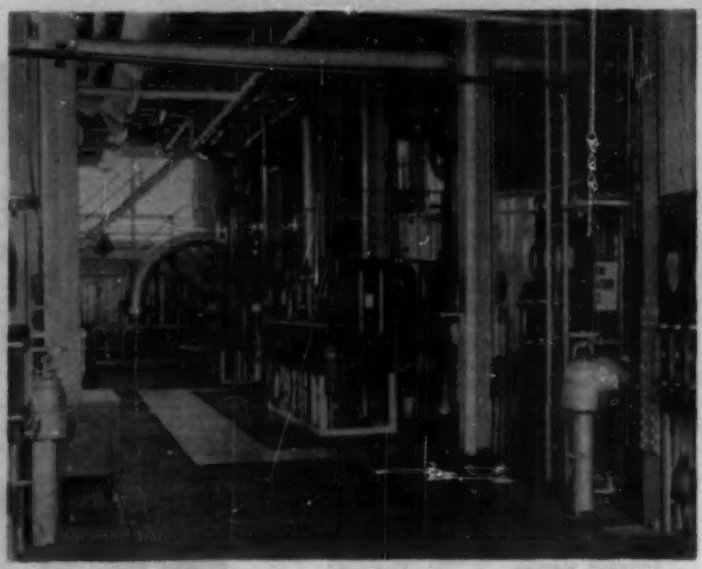

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Three new refining twists

Standard Oil of California, UOP, Houdry launch new processes

Figure 1. Isocracking unit.

THIS FALL has seen an unusual flurry of new refining processes. Worthy of more than passing note are three. Standard Oil of California's "Isocracking," Universal Oil Products' "Merox" process, and Houdry's new "Litol" process.

Economical cracking of refractory distillate feed stocks to very high octane gasoline components—this is the key to the importance of "Isocracking", worked out over several years at California Research, subsidiary of Standard Oil of California. Typical feeds are heavy cracked naphthas, light cycle oils, coker distillates: product is gasoline blend stock which, after reforming, has a research octane rating of 103-105 F-1 with 3 ml of TEL.

Yield of high quality gasoline is said to exceed 100% volume, with simultaneous production of substantial quantities of isobutane.

Results of the Isocracking treatment are summed up by Standard of California:

- The light product fractions contain isoparaffins which are far on the iso side of the theoretical thermodynamic equilibrium;
- Heavy aromatics are cracked without substantial saturation or loss of ring structure;
- Aromatics are demethylated without production of methane;
- Heavy naphthenes are cracked without appreciable loss of ring structure and yield naphthenes in the C_7-C_8 boiling range;
- Naphtha fractions are produced which can be catalytically reformed to the 104-108 octance level in high yields and at moderate severity.

Details of the catalyst employed have not been disclosed. Standard will only say that more than 2,000 catalyst screening tests were performed during the research program.

Economics are said to be favorable; cost of an Isocracking facility is quoted at from $350 to $450 per daily barrel of feed. Pay out time before taxes is estimated at under two years.

License to provide design, engineering, and construction services for the Isocracking process has been granted to Bechtel.

Sulfur removal

"An inexpensive way to remove harmful sulfur compounds from a wide range of gasoline and light distillate oils." This is how Universal Oil Products describes its new "Merox" process, now available for licensing.

Two major applications stand out, says UOP. It can, they say, be operated to remove mercaptans from gasoline and lower boiling fractions, in which case there is a reduction in the sulfur content of the material treated, or it can be used to "sweeten" stocks in which extraction is not of interest, by converting the mercaptans to disulfides.

UOP sees important applications to treatment of jet as well as conventional fuels.

Catalytic oxidation

The Merox process functions by catalytic oxidation of mercaptans to disulfides in a caustic solution at ambient temperatures, with atmospheric oxidation. The disulfides formed are insoluble in the solution, and can be removed by a gravity separator.

Catalyst life for commercial units has exceeded 20,000 barrels per pound, says UOP, which works out to less than one tenth of a cent per barrel of oil treated.

Purification plus dealkylation

Also available for immediate licensing is the "Litol" process, developed by Houdry Process Corp. in cooperation with a "large Eastern steel company." This is a dual-purpose, one-step catalytic process for purification and dealkylation of aromatic light oils. Products are benzene, toluene, and xylene, said to meet stringent purity specifications.

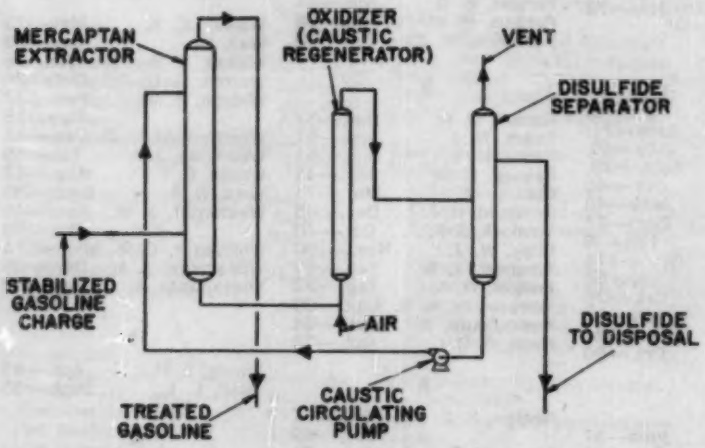
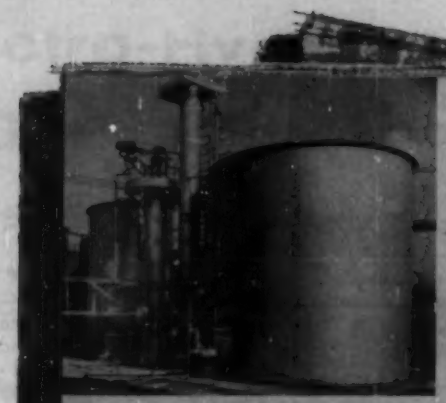


Figure 2. Merox extraction process—schematic flow diagram.



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CEP

COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts. Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

1) Abstracts submitted for publication must follow the form published in *CEP* (January, 1959) and in the *Guide*.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o A.I.Ch.E. in New York.

Flange rating (031)

K. Davis and Wm. Levy
Design Division
E. I. du Pont de Nemours & Co.
Wilmington 98, Delaware

Description: The program calculates stresses in flanges for which the dimensions and service conditions are given.

Method: It follows the method in "Modern Flange Design", *Taylor Forge Bulletin 502*, in detail. Values of shape factors are calculated from the equations in "Development of General Formulas for Bolted Flanges" by Waters, Wesstrom, Rossheim, and Williams (Taylor Forge Company—1949). Flanges rated by this calculation meet or exceed the ASME Pressure Vessel Code requirements.

A special form for input specifies type, dimensions, allowable stress, working pressure, and gasket to be used. The output consists of the required and actual bolt area, the stresses in the flange, and type-outs if:

Bolts are too small.

Radial clearance between bolt circle and hub is too small.

Tangential spacing will not accommodate bolts.

Bolt spacing exceeds

$$2d + \frac{6t}{m + .5}$$

All the intermediate results usually produced in a manual calculation may be printed.

Computer: LGP-30.

Program language: 24.0 Floating Point Interpreter, as modified by Du-Pont.

Running Time: One to four and one-half minutes per flange.

Comments: Only flanges having the gasket entirely within the bolt circle can be calculated by the program. Integral or loose flanges with or without a hub can be handled. Lap flanges are calculated as a special case of loose flanges.

The program is thoroughly debugged and extensively used for design as well as rating.

Availability: The manual on this program will be submitted for publication by January 1, 1960.

Pressure drop in piping networks (030)

R. J. Hunn
E. I. du Pont de Nemours & Company, Inc., Engineering Department Newark, Delaware

Description: This program calculates flow and pressure distribution in a piping network connecting fixed sources and sinks. The network may consist of loops, radial branches, or a combination. Elements of the network may be equivalent lengths of pipe or pumps, or other equipment in which the pressure loss or gain is a function of flow. Elevation differences can also be included in the system. Non-planar networks (having cross overs) can be handled. The program is limited to problems where the assumption of an incompressible fluid does not introduce appreciable error, although gas problems not involving critical flow can be solved by special handling. The program will handle up to 450 members and any number of loops. The Hardy Cross algorithm and fixed point arithmetic is used.

Computer: Basic (2000-word) IBM-650.

Program language: SOAP (Symbolic Optimum Assembly Program).

Running time: 7 seconds per member per iteration. (Number of iterations is of same order of magnitude as number of loops.)

Comments: Extensive data checking and error trapping is included. All input data appears edited in output together with complete listings of flow in each member and pressure at each node.

Availability: The technical report covering this program will be rewritten by Du Pont to conform to A.I.Ch.E. standards if sufficient demand develops to warrant publication.

Minimum reflux for distillation by the Bachelor method (032)

R. M. Baer, J. D. Seader, and R. D. G. Crozier
Mathematical Services and Engineering Research Groups
California Research Corporation
Richmond, California

Description: This program calculates the minimum external reflux rate for the specified split of two key components in a multi-component mixture according to the iterative method of Bachelor, *Pet. Refiner, 36*, No. 6, 161 (1957). The method is applicable only to continuous distillation columns with a single feed and two products (distillate and bottoms). Any type of condenser may be specified. The method does not assume either constant relative volatility or constant molal overflow. Split key feeds are easily handled. The feed may contain up to 17 components.

Compute: Datatron 205, 4000 words storage, card input and output, and floating point unit.

Program language: Datatron 205 Machine Code.

Running time: Twenty minutes to one hour, depending on the number of components in the feed.

Comments: The Bachelor method is the most accurate minimum reflux program available. It has been used successfully to obtain the minimum reflux requirements for more than 40 distillation columns. It has proved to be an excellent basis for determining an actual operating reflux for a given separation.

Availability: A manual will be prepared if sufficient interest develops.

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industrial news

R. W. Schuler, *Monsanto Chemical Co.*

New tools for engineering research

Borrowed techniques from aircraft, missile, weapons industries may lead to basic revolution in chemical engineering concepts.

With greater penetration and understanding of the fundamentals underlying the behavior of complex systems, the aerodynamicist, the chemical engineer investigating non-Newtonian fluids, and the hydraulics engineer may have more in common with each other than with their colleagues in the same laboratory. The theory and mathematics of fluid dynamics, if sufficiently generalized, is the same no matter what the formal training or title of the researcher. These forces are leading to a reorganization and condensation in engineering and science, and constitute a countercurrent to present emphasis on specialization. Just as forms of engineering tend toward unification on a more fundamental plane, so too will the sciences, and—farther in the future—engineering and science tend to merge.

Fluid dynamics

It is not surprising that a heavy share of the new tools for chemical engineering research derive from burgeoning aircraft, missile, and spacecraft technologies. Many chemical engineering problems, hitherto largely unsolved because sufficiently sophisticated techniques were lacking, are closely related to aerodynamic problems. Main difference is that the aerodynamicist is largely concerned with exterior fluid dynamics, while the chemical engineer must understand fluid flow within systems. Furthermore, both are intensely interested in high-speed gas reactions under extreme conditions.

Many research tools from the aircraft industry are immediately applicable to internal fluid dynamics. Schlieren and shadow graph techniques coupled with high-speed photography have been particularly effective in studying gas mixing and flow in complex geometries. For such studies, where high local velocities are essential, we are usualy restricted to model scale for the same reasons as the aerodynamicist — inadequate gas supply. For the chemical engineer this problem may be more severe because he must deal with fluids other than air, although his problem is somewhat mitigated because he need not be concerned with wall or boundry effects on the model such as normally encountered in wind tunnels.

Figure 1 represents the essential components of a schlieren system adapted to fluid dynamic studies in Monsanto's Engineering Research Section. Major components are: 1.—a high-speed light source, providing exposures of less than 1 microsecond; 2.—slit and collimating optics; 3.—model section between two optical flats arranged on vertical and horizontal racks for choice of field of exposure; 4.—schlieren lens and adjustable knife edge; 5.—view camera or high-speed motion picture camera.

Figure 2 shows a typical exposure of a mixer model for mixing two dissimilar gases in milliseconds. While schlieren techniques have often been used in the past to study flames with their large differences in refractive index due to temperature gradients as well as composition, the illustrated system is sufficiently sensitive to detect differences in refractive index due to composition alone at exposures in the microsecond range. The benefits of using a purely optical method, with its absence of probes within the system under study, are self-evident. This technique is readily adaptable for studying such diverse problems as shock wave generation in flow systems; heat transfer; diffusional operation in gas-gas and liquid-gas systems;

continued on page 92

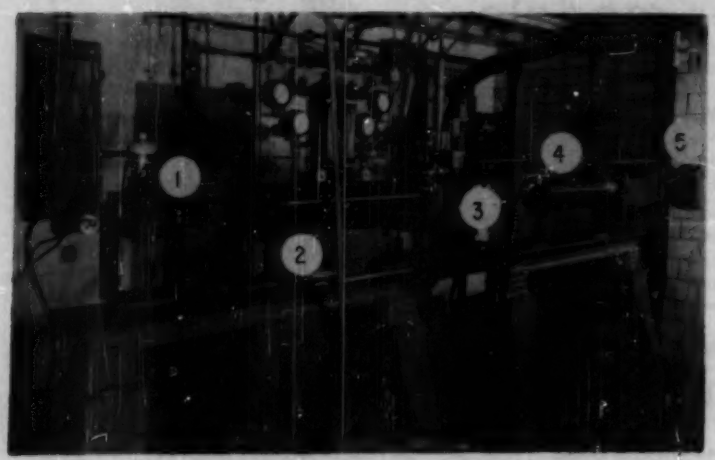

Figure 1. Schlieren system for fluid dynamic studies (Numbers in text).

Figure 2. Schlieren photo of sonic gas mixing.

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Send in your questions on stainless valves and fittings to Carl Tylka, Cooper Alloy Technical Service Director.

Q. *Is it possible to obtain a valve which, like a globe valve, possesses linear throttling characteristics, but which also, like a gate valve, has low fluid pressure drop across it when fully opened?*

A. Not throughout the entire flow range of the size valve being considered. A very close approximation, however, may be attained with a Flex-Plug type design (a unique new valve patented by Cooper Alloy), which provides linear throttling response up to 90% of full valve flow. The 10% balance of the upper flow region would exhibit a typical gate valve flow pattern.

Q. *How can one prevent oxidation of active ferrite ion on the fluid side of a cast stainless valve body?*

A. This type of corrosion is commonly found on untreated cast stainless surfaces only, and may be caused by foundry, machinery, and handling techniques. Proper pickling and passivation with thorough mechanical cleaning will generally rectify this, though in some cases actual weld repair of the contaminated surface is required. Since this is a surface condition only, machining or grinding will also help.

Q. *What type of valve do you recommend for manual-control services where minimum pressure drop is required?*

A. In the absence of more detailed knowledge of the problem, I would tentatively recommend an angle valve. The pressure-drop characteristics of this type valve are less than 50% those of conventional globe valves.

Q. *Is it advisable to specify installed valve position on an order?*

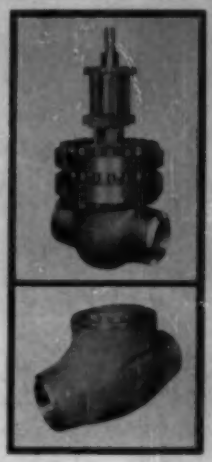
A. Definitely. By inclusion of this information, definite design considerations can be incorporated, especially in cases where backseat leakages are critical and mechanical valve operation is involved.

Q. *Is it advisable to install valves smaller than the accompanying pipe sizes?*

A. Where flow and pressure considerations so permit, it is not only advisable but also economically beneficial.

Q. *Why aren't valve bodies with butt weld end connections made shorter?*

A. To prevent distortion of the seating surfaces during installation. The longer length is required for heat dissipation during welding.



Above left, Cooper Alloy 16" cast stainless gate valve ready to receive gear motor drive; lower left, Cooper Alloy 12" cast check valve. Both are rated for 2900 psi service at 670°F. Official AEC photo above shows them in place in nuclear process line.

Cooper Alloy cast stainless valves spurt ahead of competition to win acceptance in AEC's Spert III reactor program

Cast yield strengths of 23,000 psi, plus cost savings of 40%, do the trick!

This is a Cooper Alloy success story in another "first": casting of stainless valves and fittings to strength levels actually surpassing those previously possible only in forgings—and doing it all at a 40% saving to the customer!

The story starts, naturally, with the AEC's valve and fitting specifications, which are rugged indeed. They have to be certified to function continually at elevated pressures and temperatures (2500 psi, 670° F.), under which conditions leakage, corrosion, and other operational problems are magnified enormously over those encountered in normal process work.

Prior to turning to Cooper Alloy, the contractor for the AEC cancelled a large valve order from another supplier, because the latter could not meet the exacting physical specs without changing the material specs. Cooper Alloy was given the order on the basis of producing to meet AE and AEC specs. Cooper Alloy valves and fittings are currently in operation in the AEC's Spert III installation at Arco, Idaho. Included are nuclear fittings, and motor and manual operated gate, globe, and check valves in various sizes.

How does Cooper Alloy do it? Through the use of the most advanced foundry methods, meticulous attention to conditions, and an exact balance of chemical composition to develop the maximum strength characteristics inherent in the complex structure of stainless alloys. All products, naturally, are elaborately tested and guaranteed before delivery.

As if the AEC's specs were not stringent enough, there is now a bonus to the story: during production, Cooper Alloy technicians worked out ways of producing cast strengths higher than those required, and proceeded to produce all fittings and valves to these higher, self-imposed standards—at cost savings of 40% over forged valves and fittings!

Unusual, yes, but not to Cooper Alloy. It's typical of the quality bonus you get when you buy from Cooper Alloy. For further information, write to Cooper Alloy Corporation, Hillside, N. J.

For more information, turn to Data Service card, circle No. 30

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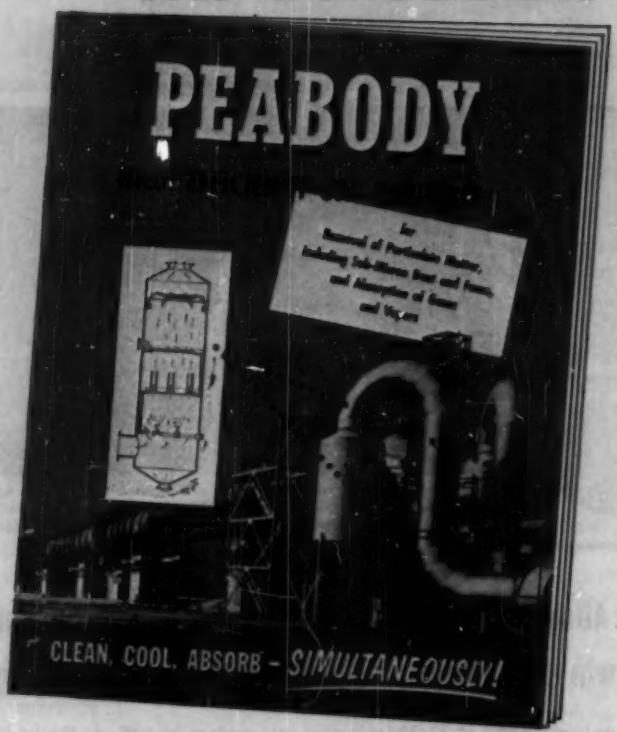

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For more information, turn to Data Service card, circle No. 23

New tools

from page 90

erosion in fluid-solid systems; burning velocities and propagation.

Reactor design

Perhaps the single most complex problem for the chemical engineer is the design of reactors. Inadequacies in reactor design have led to more out-and-out failures and loss of plant capacity than errors in any other component. Furthermore, "de-bottlenecking" of plants that suffer from this shortcoming is often expensive or, where competing reactions dominate, even impossible. Model studies of fluid flow in reactors can in many cases eliminate potential weaknesses in design.

The dynamic approach

A useful technique for studying the fluid dynamics of systems is the dynamic-response method. Originally developed by the systems engineer to provide information for designing closed control loops, this is also a valuable engineering research technique for non-system engineering problems. More can be learned, and often more rapidly, about a system by transient testing than by conventional steady-state studies.

An important practical benefit of dynamic experiments is that we need only consider the input and output of the system under study. Like optical methods, it eliminates the necessity for inserting probes into the system, hence it may be used to advantage even where steady-state experiments are equally applicable. Further advantage of dynamic techniques over steady-state methods is the speed with which the influence of independent variables can be scanned. In steady-state experiments, for instance, it is not uncommon that a system must be operated for an entire day before true steady-state behavior is attained. Even then it is frequently impossible to preselect the exact conditions under which the desired run is to be made. In dynamic experiments we need not necessarily attain such steady-state behavior, and in scanning the response of the system to changes in a given independent variable it may be possible to change this variable continuously while at the same time scanning the output.

Dynamic studies represent a long step in the realization of an engineering research philosophy characterized by:

continued on page 94

Clarity control is <u>almost</u> this easy with DICALITE Filteraids

FIRST REASON is, of course, that Dicalite supplies the greatest variety of filteraids to handle practically every type of fluid . . . a complete family of top-quality diatomite filteraids of different performance characteristics, plus Nerofil carbon-based filteraids and other special filteraids developed and processed for particular applications.

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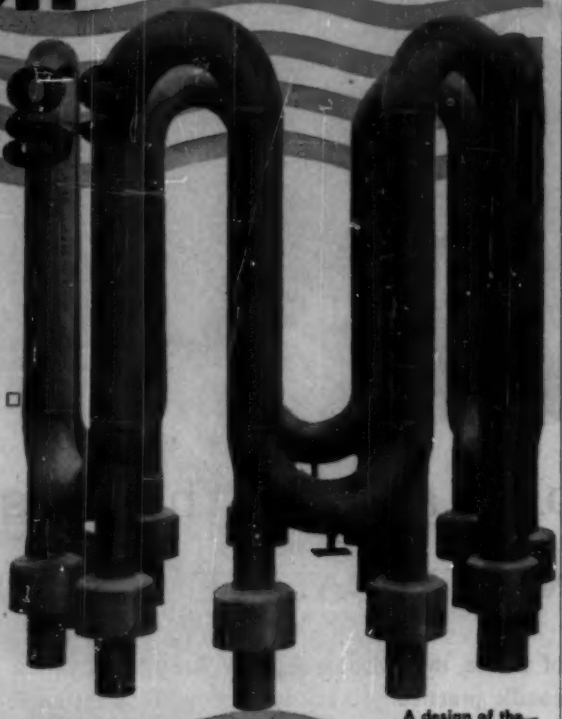

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DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Data Service card, circle No. 31

New tools

from page 92

- Elimination of large-scale pilot plants;
- Increased emphasis and expenditure on instrumentation and experimental design prior to actual experimentation, followed by a relatively short period of experimental work.

Kinetics and catalysis

Today's researcher is forced to search for new developments in regions of ever increasing rigor, that is, shorter durations, higher (or lower) temperatures, higher (or lower) pressures. It is, therefore, understandable that some of the chemical engineer's newest kinetic techniques and ideas on reactor technology should derive from the aircraft and missile fields. One new idea is the "rocket" reactor. Enormous quantities of material can, in theory, be processed in small and inexpensive equipment. Although the rocket reactor has not reached the industrial stage, its influence on the design of high-temperature oxidation and pyrolytic processes is evident.

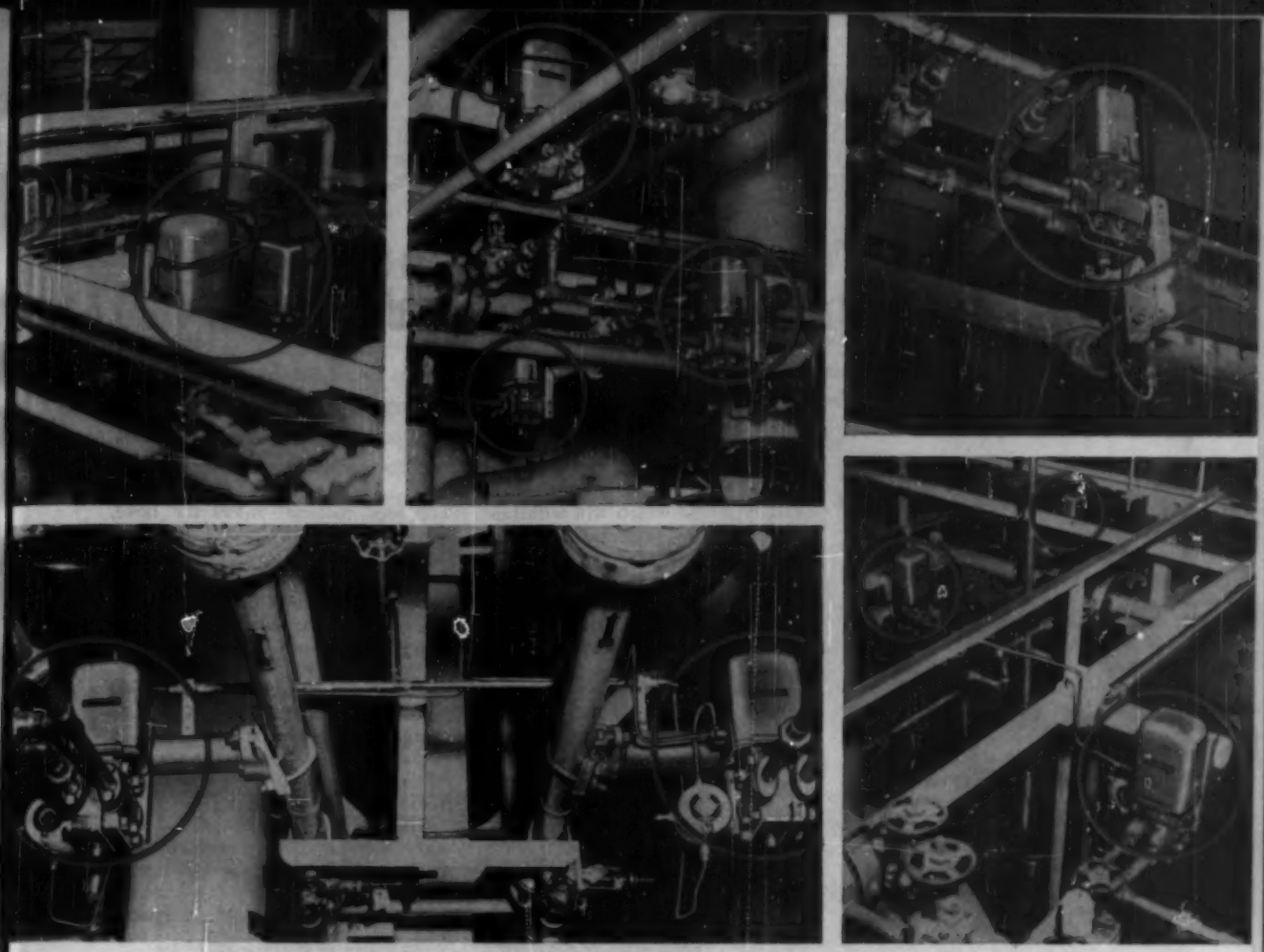
An important, relatively new, tool for kinetic studies is the "shock" tube, which stems directly from its earlier use as a hypersonic wind tunnel. For chemical engineering studies, the shock tube has been modified to subject the reacting mixture to a single shockwave with its attendant, almost instantaneous, rise in gas temperature followed by a rapid adiabatic quench. This is accomplished by a triggering device which bursts a diaphragm into a dump tank where the shock wave is dissipated after a single pulse.

New hypotheses on catalytic theory, as well as associated experimental techniques, have evolved in recent years from solid state physics. Research is currently going forward to verify the theory of catalytic activity in terms of the electronic properties of the solid. We may in the near future be able to select a limited number of catalysts on theory alone.

Mechanics

The current trend toward increasing severity in operating conditions, and greater sophistication in design, has placed more rigorous requirements on materials of construction. Experimental stress analysis, a method borrowed from mechanical and aeronautical engineering, is proving of increasing importance in developing knowledge of metals and designs for high pressure operations in the chemical field.

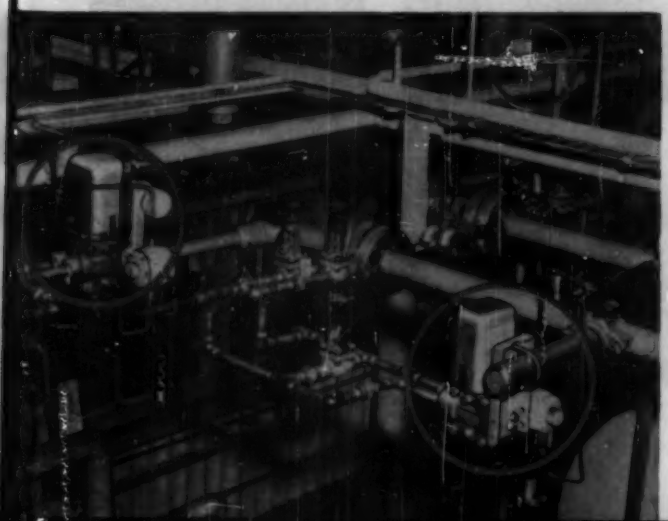
For more information circle No. 20



A few of the more than 100 Foxboro d/p Cell Flow Transmitters installed at Missouri Chemical Works of Hercules Powder Company, Louisiana, Missouri.

Hercules' Missouri Chemical Works reports:

"Foxboro d/p Cells* always accurate . . . never need re-calibration"



At Hercules Powder Company's 540-acre Missouri Chemical Works, there are over 100 Foxboro d/p Cell Transmitters in operation today — providing high-speed flow measurement and transmission throughout the ammonia, formaldehyde, methanol and pentaerythritol plants.

"Reliability is the big thing," according to Hercules instrument engineer J. J. VanShaik. "We can install a Foxboro d/p Cell and forget it. Once it's calibrated, we know it'll stay that way. We never even stock spare parts."

Hercules especially likes the Foxboro d/p Cell for flow control. "Gives us closer control," says instrument engineer H. McCombie. "Eliminates one possible source of inaccuracy and maintenance trouble in the control loop."

Let Hercules' experience be your experience — with Foxboro d/p Cell Transmitters as the basis for your control system. Write for full details in Bulletin 13-11A. **The Foxboro Company, 3312 Neponset Avenue, Foxboro, Massachusetts.**

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New developments in centrifugals

Improved metallurgy, new designs for mechanical seals and paring devices, extend range of processing capabilities.

For high-capacity liquid-liquid separation, the high-speed disc centrifuge may be employed advantageously. To increase capacity and efficiency, the number of discs and the area of the discs may be increased. The centrifugal bowl may then be increased to a maximum diameter, within the limits of metallurgy.

Figure 1 shows a Hermetic disc bowl centrifuge, a high-capacity, high-efficiency unit embodying the advantages of thin-strata liquid separation under positive pressure operation. The feed material enters at the bottom, passing into the rotating spindle and upward into the separator bowl. The light and heavy immiscible liquids are separated and discharged under operating pressure at the top of the bowl through separate mechanical seals into pipes which carry the separated liquids to the next stage. The feed material entering the centrifuge, as well as the separated liquids leaving it, are under pressure and, by employing specially designed mechanical seals on both the inlet and outlet, pressures up to 10 atmospheres are common. It is possible to use a balanced type seal which will withstand higher operating pressures. By use of the newer elastomers for O-rings and other sealing rings within the centrifuge, it may be made suitable for operation in excess of 150°C.

Feaure of the unit is a mixing device which consists of a series of shear bars located in the upper portion of the rotating spindle. This type of mixing may be advantageously employed when it is desirable to contact two immiscible liquids for a short time and to immediately separate the products of reaction. In this case, the period of contact between the two liquids is only a fraction of a second before they enter the separating zone of the centrifuge. Materials may be mixed and separated under pressure, out of contact with the atmosphere.

Self-opening units

Interesting new development is the self-opening, high-capacity disc bowl centrifuge (Figure 2). With this unit, solids may be removed and immediately discharged from the separator. It functions as a separator in the same manner as the standard disc bowl. The feed material enters the bowl, rotating at a high speed, and separates into two or three phases. The feed material then flows up the disc stack, with the light material separating and flowing inward, while the heavy liquid or liquid-solids flow outward; the solids deposit against the bowl wall. The liquids, both light phase and heavy phase, are discharged at the top. A paring device, or mechanical seals, can be used for either or both of the discharged liquids.

The solids are collected in the bowl and intermittently discharged through a series of slots in the bowl wall. When it is necessary to discharge the solids, the sliding bowl bottom is forced downward by liquid hydraulic pressure.

Principal application for this type of centrifuge is where the sludge content is high enough to cause frequent bowl cleaning in a standard disc separator. In the food industry, an important advantage is that this unit can become part of a sanitary "clean-in-place" product line, where shutdown and disassembly for cleaning is performed only rarely.

Nozzle types

If the solids concentration is too high, a self-opening centrifuge would

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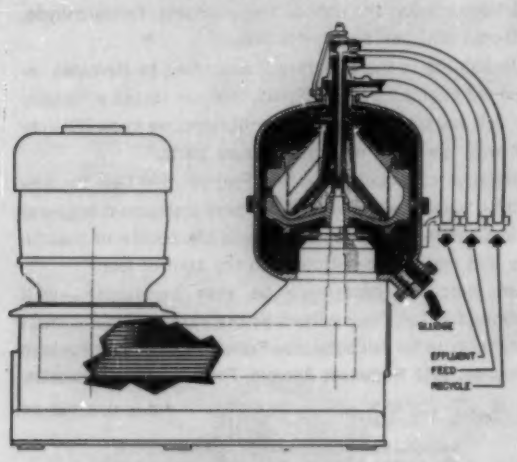

Figure 3. Nozzle centrifuge

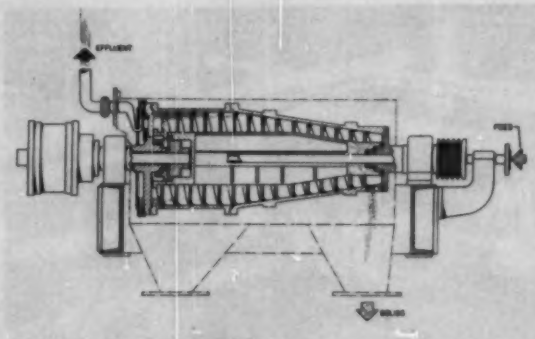

Figure 4. Conveyor bowl type

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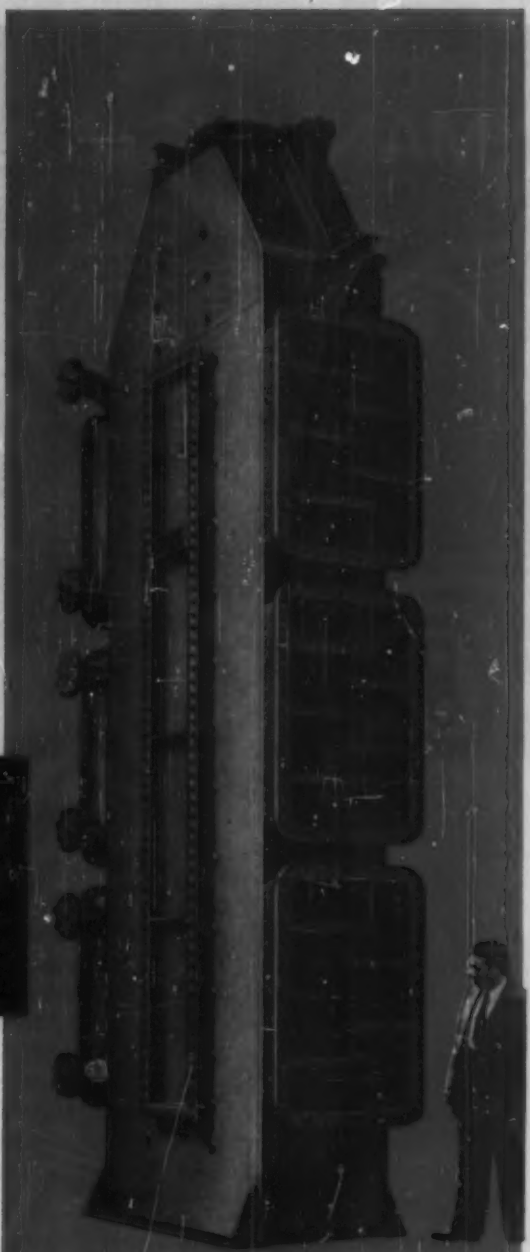

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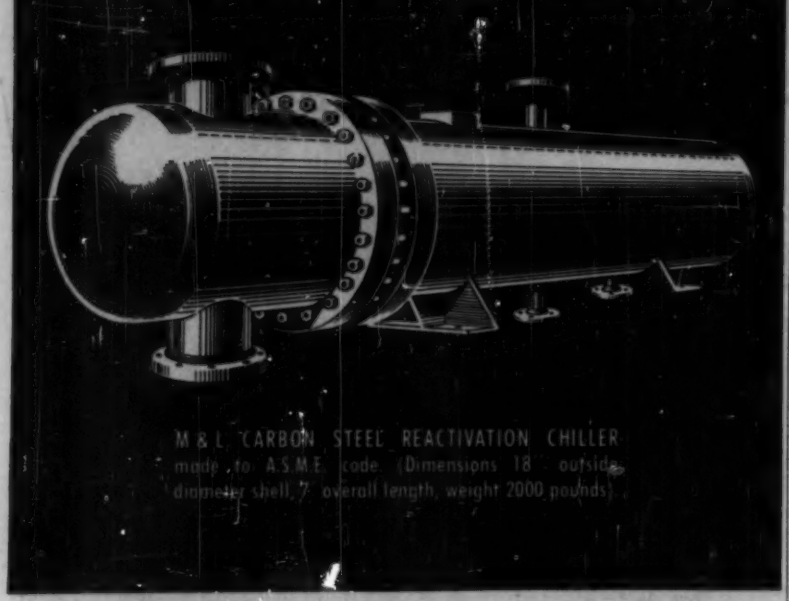

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New developments

from page 96

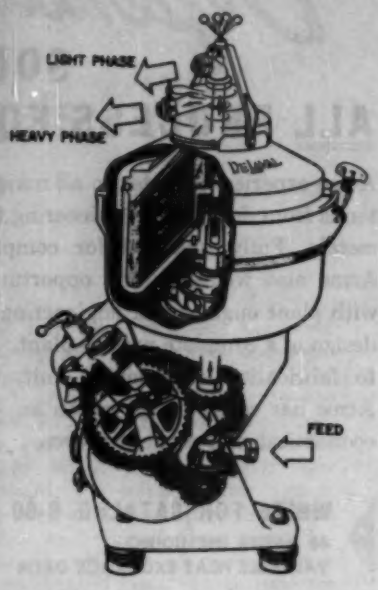

Figure 1. Hermetic disc bowl centrifuge

be continually discharging without allowing enough time for separation of feed material. When the solids content of the feed rises to over 6% by volume, the nozzle centrifuge (Figure 3) is generally considered the most logical machine. Separation in the nozzle centrifuge takes place with the standard disc stack. The solids are separated and forced to the outside of the bowl wall where they are continuously discharged through tangentially discharging nozzles located on the periphery of the bowl wall.

The horizontal conveyor bowl

The conveyor bowl centrifuge (Figure 4) is ideally suited for removal and concentration of solids from slurries. Essentially, it is a horizontal hollow bowl unit which subjects the solids to high centrifugal force.

A helical conveyor rotating inside the bowl at slightly lower speeds conveys the solids to the conical end of the bowl where they are continually removed. The clarified liquid is continuously discharged at the opposite end of the bowl. The liquid is discharged through a paring tube. Proper setting of the paring tube will allow external adjustment of liquid depth, thereby varying the degree of clarity. A rule-of-thumb rule for application of this type of unit is that it

continued on page 100

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All the facts about Harshaw Tellerettes are contained in a comprehensive booklet discussing their application to Tower Packing.

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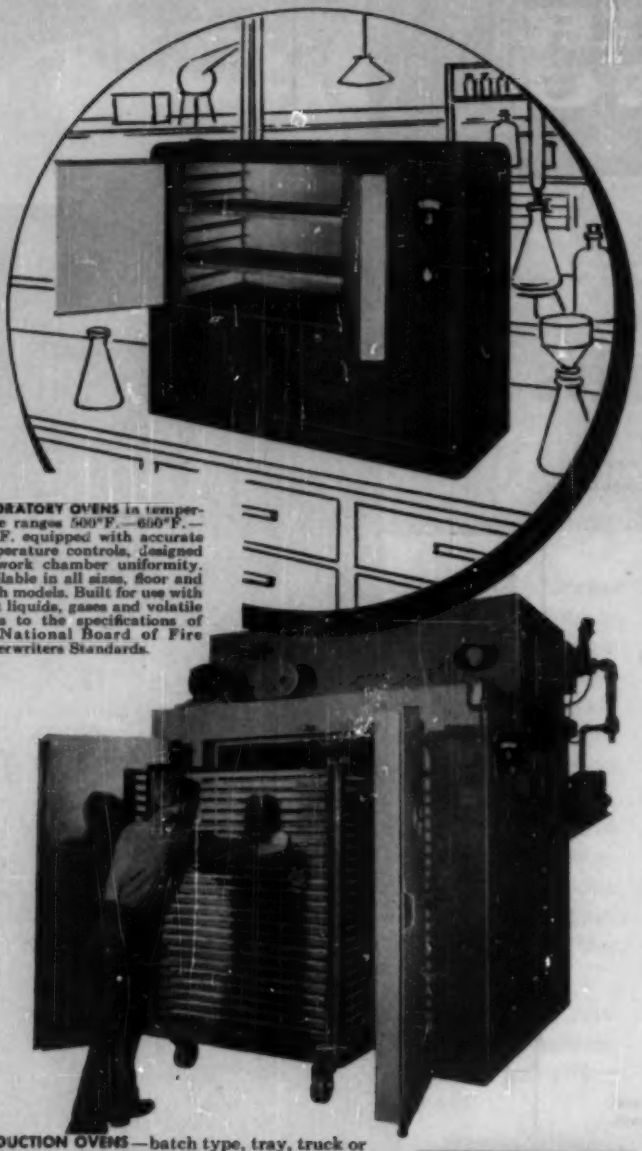

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New developments

from page 98

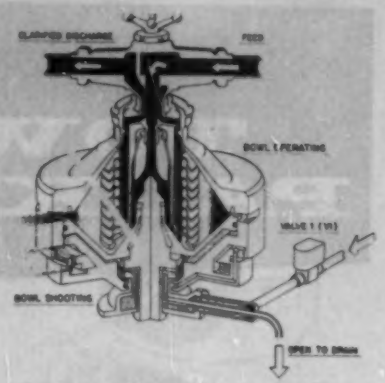


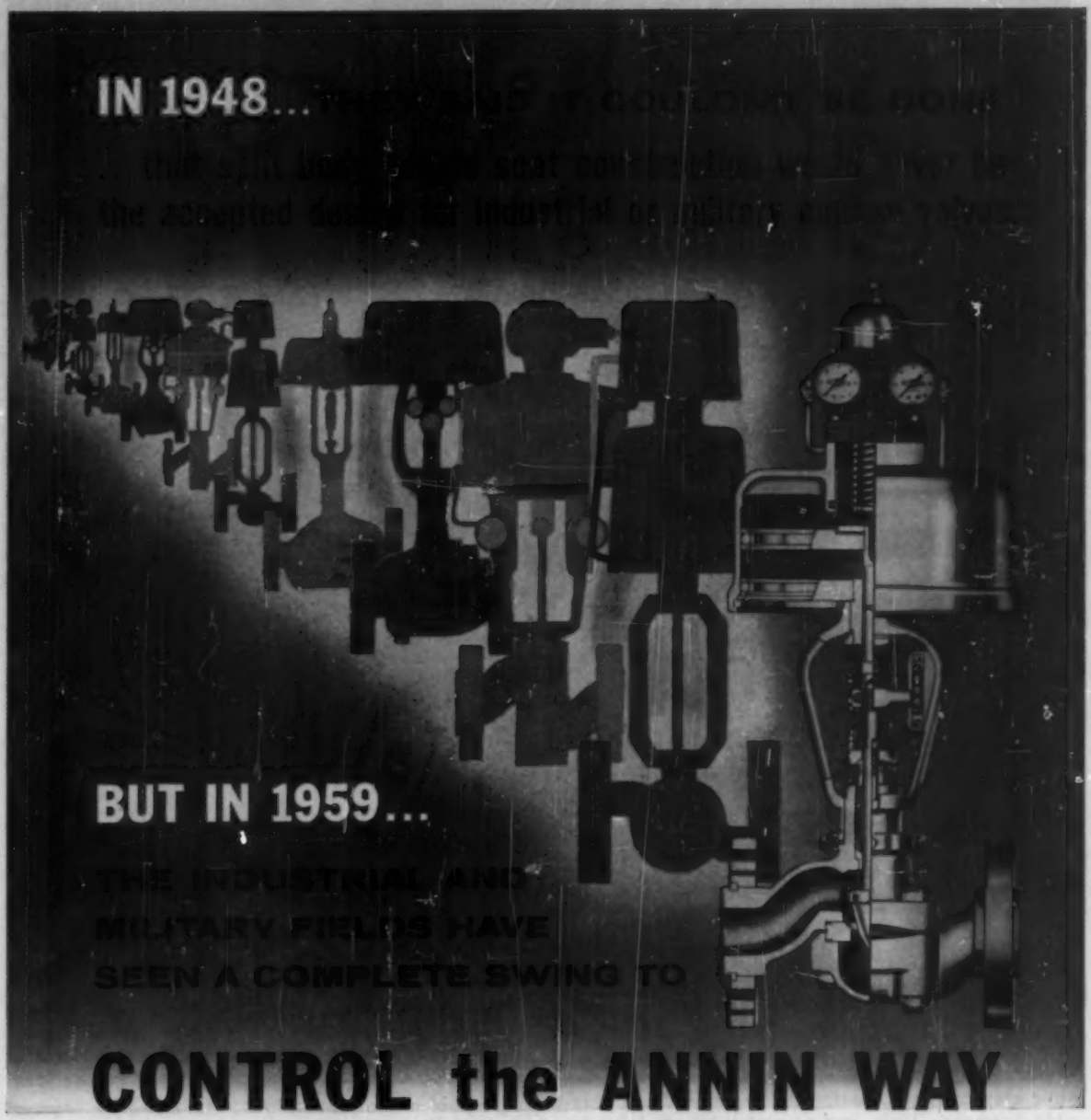
Figure 2. Self-opening disc bowl type

will separate particles of a minimum size of 20 microns at a specific gravity of 2.5 for the particle, when using water as the dispersing agent. However, by varying the bowl speed, and the corresponding conveyor speed, a wide range of solids can be handled satisfactorily. This type of unit is often used as a primary separator followed by a secondary high-speed centrifuge of the disc type, either the high-speed, straight-walled, liquid-liquid separator, or the self-opening type.

Dow Chemical goes into the processing of crude thorium materials with the acquisition of Thorium Ltd., United Kingdom processing firm. One of the principal suppliers of refined thorium oxide and salts in the British isles, the Lancashire firm also exports these materials. Much of its production is cerium compounds, particularly cerium oxide optical polishing powders. The Rio Tinto Company, Ltd. London, and Dow's Swiss subsidiary, Dow Chemie, will operate Thorium Ltd., as Rio Tinto Management Services Ltd.

Nearing completion in Pennsalt's $6 million modernization program on chlorine caustic soda is the new 50 percent evaporating facility at the Wyandotte, Michigan, plant.

A specially designed higher thrust solid fuel rocket propellant is now under development at B. F. Goodrich. Contract for the propellant, which will also allow for greater safety in shipment of the fuel, was awarded by Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.



CONTROL the ANNIN WAY

In 1948 split body construction and powerful high speed, precise positioning pneumatic piston actuators were available from only one source—Annin. Today, more than a decade of accumulated experience in this type of valve design makes Annin features and performance records the best in the valve industry. Contrary to published statements by critics ten years ago, Annin-type construction is now available from many sources. But when tempted to consider *mere-replicas* of Annin valves, remember this—they might give you a few Annin features, but when you specify Annin Valves you get them all!

Annin VALVES

THE ANNIN COMPANY
1040 South Vail Avenue
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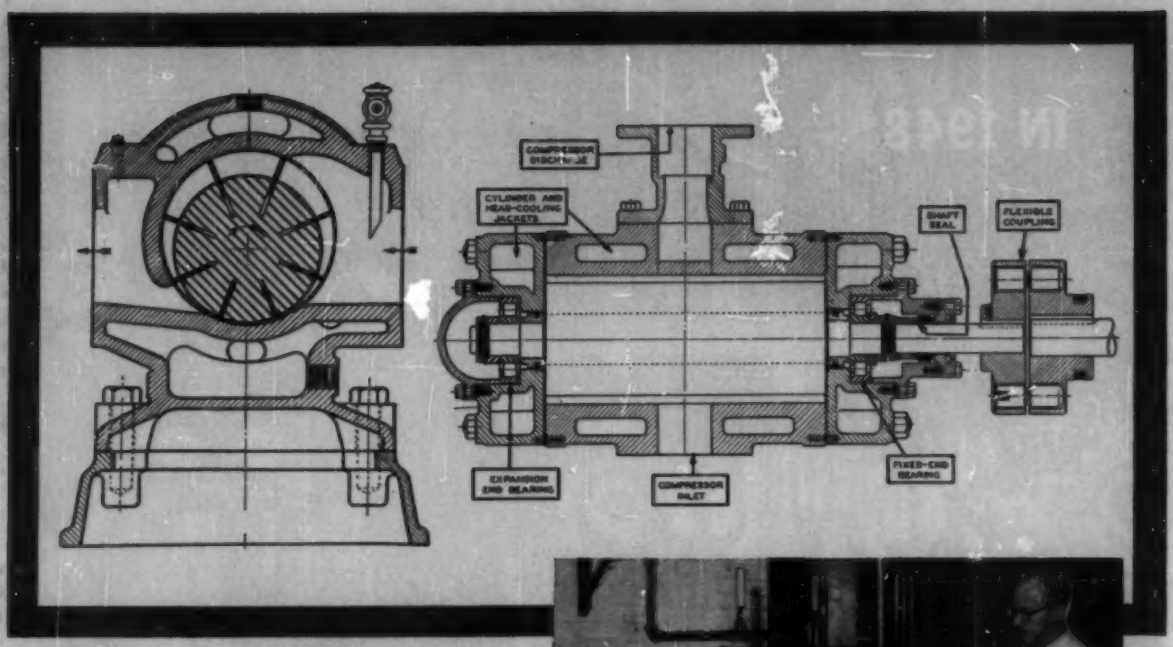

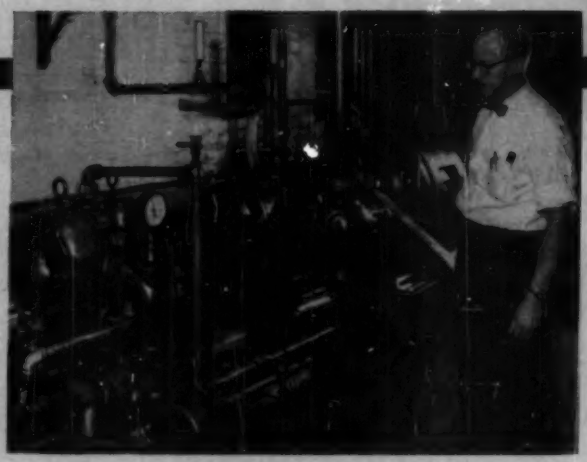

Hard service never affected this Fuller rotary's original output—230 cfm. of air at 90 lb. G., reports Mr. Schott, chief engineer, Thomas C. Wilson, Inc., Long Island City, N.Y.

FULLER ROTARY COMPRESSOR RUNS 13 YEARS WITHOUT DOWNTIME

A Fuller rotary at Thomas C. Wilson, Inc. got its first maintenance shutdown recently, for renewal of roller bearings and rotor vanes—after running without downtime since 1945.

4 years of 24-hour service. The Wilson plant makes tube cleaning equipment, tube expanders and portable pneumatic tools, and so makes heavy daily demands on shop air. For the first four years, three-shift operation kept the Fuller rotary running round the clock. Since 1949, it's been working eight-hour shifts.

Simple design means trouble-free service. Besides bearings, the only moving parts in a Fuller vane-type rotary compressor are the cylinderical rotor and the blades. These compensate for wear automatically. Cylinder head slips off, permitting blade and bearing inspection in a matter of minutes.

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C-340

Write today for detailed information on the full line of Fuller rotary compressors for in-plant services, gas gathering, and industrial refrigeration.

See Chemical Engineering Catalog for details and specifications

FULLER COMPANY
174 Bridge St., Catasauqua, Pa.
SUBSIDIARY OF GENERAL AMERICAN TRANSPORTATION CORPORATION
Offices in Principal Cities

Fuller
pioneers in harnessing AIR

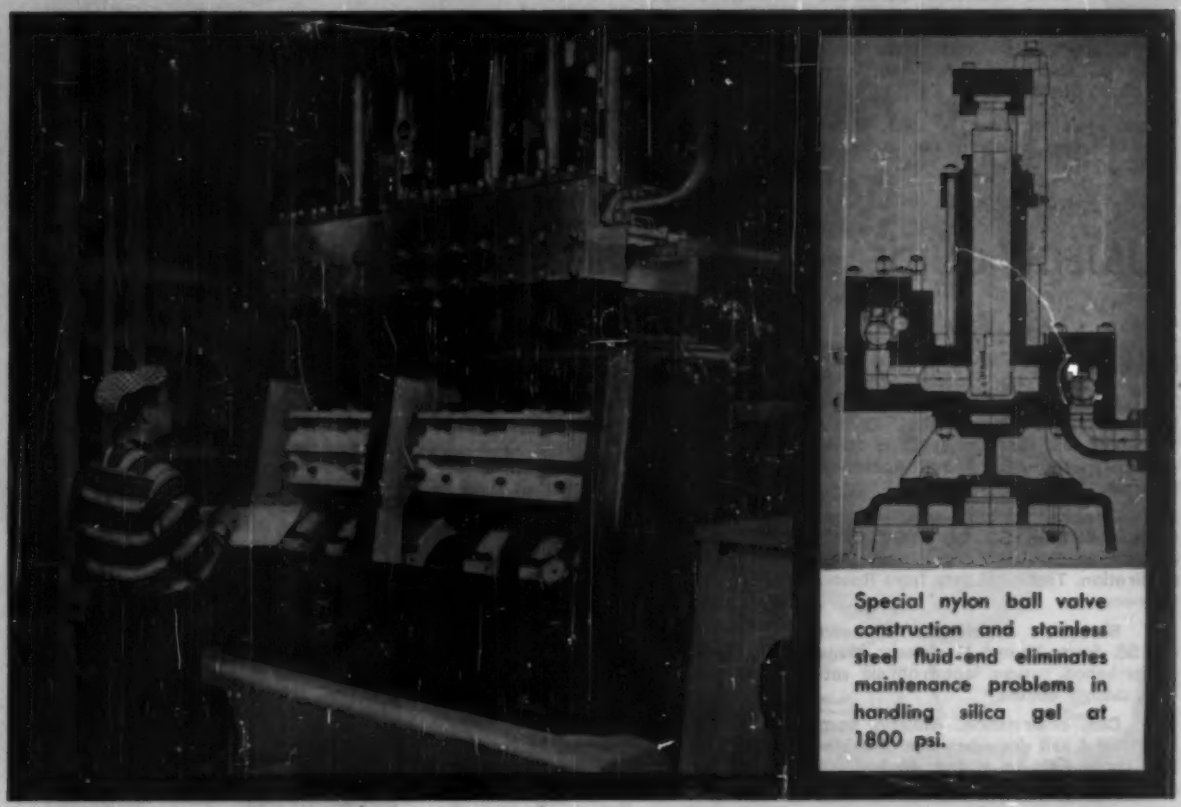
PIONEERS OF HIGH-EFFICIENCY VANE TYPE ROTARY COMPRESSORS SINCE 1930

For more information, turn to Data Service card, circle No. 8

The following 2 pages that appear to be missing are reader service cards and have been removed.

AT DAVISON CHEMICAL LTD.

Aldrich pumps tame highly abrasive, corrosive slurry in high pressure spray drying operation



Special nylon ball valve construction and stainless steel fluid-end eliminates maintenance problems in handling silica gel at 1800 psi.

When Davison Chemical Ltd. built its new plant in Valleyfield, Quebec, for the production of petroleum catalysts, a major problem was to find a pump that (1) had the abrasion and corrosion resistance to stand up in a continuous high pressure process without downtime or excessive maintenance and (2) could maintain the steady pumping pressures necessary to control particle size, density and porosity of the spray dried product.

What was done: Davison Chemical engineers called on Aldrich for help and the result was the special valve design shown. After two years of continuous operation, the Aldrich pumps continue to deliver constant pressure without major overhaul. The General Manager of the plant reports: "We are quite pleased with the performance of these pumps."

How Aldrich can help you: Solving special pumping problems for the chemical industry is the most important work we do. We would welcome the opportunity to discuss your specific problems . . . no matter what the liquid or slurry, or how high the pressures. Standard Aldrich Pumps range from 25 to 2500 hp. Pressures to 30,000 psi. See our insert in Chemical Engineering Catalog for condensed data. Aldrich Pump Company, 20 Gordon Street, Allentown, Pennsylvania.

the toughest pumping problems go to ALDRICH

For more information, turn to Data Service card, circle No. 62

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 104*

for entire line of acid-proof valves, made of solid chemical porcelain, armored with "Tufclad." Circle 21.

Valves, control (p. 101). Data from Annin on split-body, single-seat construction. Circle 70.

Valves, stainless steel (p. 91). Complete technical info from Cooper Alloy. Circle 30.

Vessels, cryogenic (p. 27). Data from Chicago Bridge & Iron on vessels for low-temperature storage of oxygen, methane, ethylene, nitrogen, hydrogen. Circle 74.

Washers, fume (p. 129). Bulletin 90 from Maurice A. Knight shows capacities, pressure drops, horsepower requirements. Circle 80.

Water Treating Equipment (p. 113). Catalog from Hungerford & Terry. Circle 41.

Water Treating Equipment (p. 130). New 24-page Bulletin from Elgin Softener covers water softeners, demineralizers, dealkalizers, deionizers, filters, purifiers, degasitors, deaerating heaters, water treating chemicals. Circle 18.

SUBJECT GUIDE to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Aerator, bio-oxidation. Data from Permutit on the "Permaerator" for use in almost all aeration systems. Diagrams, charts, design and operating features.

302 Blowers, vacuum, small-volume. Capacities from 30 to 1,000 CFM, vacuum to 20 in. Hg in single-stage application. Technical data from Roots-Connersville.

303 Blowers, centrifugal. Bulletin F-1158 from Young Machinery gives performance curves, approximate ratings, design details.

304 Cell, chlorination. Bulletin from Diamond Alkali describes use of oxidation potential cells for control of chlorine reaction in bleaching of paper pulp.

305 Cleaner-Silencers. Bulletin 273 from Burgess-Manning describes new line of air intake cleaner-silencers, designed to insure clean air, stop intake noise.

306 Compressors, multi-stage. Data from Clark Bros. on high-efficiency centrifugal air compressors. Six case sizes, 1,000 to 8,000 hp., capacities 5,000 to 38,000 CFM.

307 Conveyors, belt. Bulletin 915 from Transall gives technical data on all types of belt conveyors with "prelubricated" idlers.

308 Conveyors, spiral. New 56-page Catalog 951 from Jeffrey Mfg. shows conveyor layouts, data on materials, capacities, conveyor selection and horsepower requirements, feeders, much other engineering data.

309 Data Processing Equipment. New 48-page Technical Publication N-07(1) from Leeds & Northrup details digital data processing and analog and digital computing systems.

310 Dispersers. Brochure 8-D from

continued on page 108

MATERIALS

367 Chemicals, textile. Union Carbide Chemicals offers new 44-page Booklet covering more than 100 chemicals for the textile industry. Applications, formulations, physical properties data on chemicals used in 41 process operations.

368 Chemical Cleaning Products. Technical Bulletin 102 from Chas. Pfizer & Co. lists cleaning products, gives use data.

369 Chlorinating Agents. New Brochure from Hooker Chemical summarizes methods and types of reactions. Extensive literature references.

370 Dimethylformamide. Bulletin from Du Pont summarizes latest data on use as PVC resin solvent. Particularly interesting in manufacture of protective coatings.

371 Esters. New 40-page Catalog from Kessler Chemical gives specifications, physical properties, solubility data on fatty acid esters of butyl and propyl alcohols, ethylene glycol, diethylene glycol, propylene glycol, glycerol, polyethylene glycols.

372 Gases, compressed. Catalog from Matheson gives data on complete line of compressed gases, regulators, auxiliary equipment.

373 Heat Transfer Fluid. Monsanto offers Booklet with engineering heat transfer data for use of "Aroclor," fire-resistant heat transfer agent that operates up to 600°F in liquid phase.

374 PVP/VA Copolymers. Bulletin AP-88 Rev. from Antara Chemicals, General Aniline & Film, gives properties, formulations, stability factors, viscosity ratings, compatibility and physiological data on vinylpyrrolidone/ vinyl acetate copolymers.

375 Resin, epoxy. Technical Information Bulletin from Koppers on "Kopox-

continued on page 108

SERVICES

379 Custom Chemical Synthesis. Bulletin from Eli Lilly & Co. describes wide range of chemical syntheses which will be performed on a custom basis.

380 Fabrication, process equipment. New Catalog Guide 25C6177P covers all equipment made by Allis-Chalmers for the process industries.

DEVELOPMENT OF THE MONTH

FREE-PISTON PUMP

(Circle 602 on Data Post Card)

A new air-operated free-piston pump, made by Crossley Machine, is said to "pump anything that flows,"—abrasives, sludges, plastics, including molten metals at temperatures to 2,000°F.

The pump has no moving parts such as motor or engine, drive shaft or belt, packing or seals. Flow is said to be completely smooth and air-free without pulsing or surging.

Standard models will have capacities ranging from 5 to 1,000 gal./min.

For Bulletin with complete specifications, cross-section drawings, Circle 602 on Data Post Card.

Complete SCOPE of WATER CONDITIONING SERVICE from...

ALLIS-CHALMERS

End algae problems

easy, low-cost way

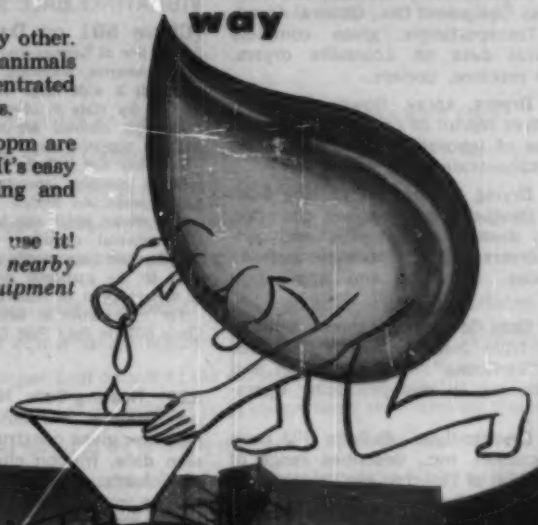
Eliminate problems of plugged pump strainers, coated heat-exchanger tubes and coated slots in cooling towers.

Control is safe . . . quick with Allis-Chalmers No. 120 Series Algaecide.

This algaecide is toxic to more algae than any other. On the other hand, it has low toxicity to fish or animals and is extremely safe to handle. Even in concentrated form it is only a mild irritant to skin and hands.

A little goes a long way! Only 2 to 5 ppm are required for effective dosage of most organisms. It's easy to feed into the system . . . and is non-oxidizing and corrosion inhibiting.

No water conditioning specialist needed to use it! Buy it and try it. *Purchase directly from your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.*



A-C ALLIS-CHALMERS

CEP'S DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 106*

Charles Ross & Son gives complete specification chart on various size units, construction details, tank sizes.

311 Dryers. Bulletin 447 from Proctor & Schwartz gives complete technical data on many types of continuous drying equipment.

312 Dryers, fluid-bed. Bulletin 88 from Raymond Div., Combustion Engineering, gives details on design, construction, operation.

314 Dryers, rotary. Bulletin 59L from Process Equipment Div., General American Transportation, gives complete technical data on Louisville dryers, rotary reactors, coolers.

315 Dryers, spray. Bowen Engineering offers reprint of case history article on use of laboratory, pilot plant, and production-scale spray dryers.

316 Drying Equipment. Catalog from S. P. Devine Mfg. describes chamber, rotary, drum, flaker, freeze, and pan-type dryers, vacuum pumps and accessories. Selection and application data.

317 Dust Control Equipment. Bulletin V-100 from Johnson March describes the "Verticone", for handling and conditioning in dust-producing operations.

318 Electric Eyes. Bulletin 522 from Photomation, Inc., describes range of application of "electric eye" techniques in process industries.

319 Evaporators. Bulletin from Goslin-Birmingham discusses development of evaporator design, facilities for fabricaton.

320 Filters. Bulletin from Croll-Reynolds on the "ClaRite" filter. Dimensions, cake capacity, flow rates, precoat info.

321 Filters, high-pressure. Built to withstand collapse pressures of more than 4,500 psi. Capacities of ½, 3, 6, and 12 gpm. Technical data from Purolator Products.

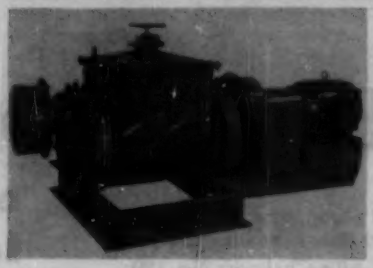
322 Fittings, tube. New folder from Parker-Hannifin offers condensed info for selection of proper fittings for various service and installation requirements.

323 Gauge, level. Catalog 1010 from King Engineering describes construction, industrial applications of the "King-Gage."

324 Gauges, pressure. Catalog G-58 from Kunkle Valve gives technical details, specification of all types, including accessories.

325 Heat Exchangers, aluminum. Bulletins from Reynolds Aluminum on "Aluminum for Heat Exchangers," and "Keys to Corrosion."

DEVELOPMENT OF THE MONTH



VIBRATING BALL MILL

(Circle 601 on Data Post Card). A new line of German-made vibrating ball mills which pulverize, micronize, and mix to critical standards a wide range of materials in either wet or dry state is offered by Schutz-O'Neill. Advantages claimed are reduced milling time and low operating cost.

Complete line includes six batch-loaded mills (from a one-pint laboratory model to a 55-gallon production model) and four continuous system models which may be used in conjunction with external classifiers. Milling media and chamber liners are readily changed to adapt the mills to the particular processing requirement of various types of materials.

For more technical data on this innovation Circle 601 on Data Post Card.

326 Heating Coils. New 32-page Product Bulletin HC-102 from American Air Filter gives construction and dimension data, friction charts, temperature rise charts, velocity and pressure drop graphs, condensate rates, heat transfer factor graphs.

327 Heating Manties. New Bulletin 4-D from Glas-Col Apparatus gives construction details, zone heating areas, power input for six sizes.

328 Instruments, nuclear. Catalog from Nuclear Measurements Corp. gives details of laboratory and monitoring instruments, survey meters, services and assemblies.

329 Mills, grinding. Monograph from Patterson Foundry and Machine is general review of grinding media and mill considerations.

330 Mills, grinding, hammer. Bulletin H850 gives engineering details, applications, specifications, capacity chart. Gruendler Crusher & Pulverizer.

331 Mixers, Catalog D from Paul O. Abbe gives details of mass & paste mixers, ribbon mixers. Specifications, dimensions, selection data.

332 Mixers. New 12-page Catalog titled "Handbook on Mulling," from Simpson Mix-Muller Div., National Engineering. Technical details, selection data.

333 Mixers, fluid, vertical. Incorporating major improvement in gear drives. Data from Philadelphia Gear on new line, available in models from 1 to 200 hp, special types to 500 hp.

334 Mixer, hydraulic. Turbine-type mixer can be varied in speed continuously from 0 to 2,000 rpm. Details and prices from Stevenson Co.

335 Models, plant layout, visual. Catalog from Visual Plant Layouts, Inc. describes uses of models in plant layout work. Cost estimation data.

336 Packings, molded. Bulletin PY-959 from Greene, Tweed gives complete technical description of new form of V-type molded packings, the "Palmetto Pyramid."

337 Piping, glassed-steel. Pfaudler introduces new glassed-steel pipe rated at 150 psi, available in 1½, 2, and 3 in. diameters. For all acids, except HF, to 350°F, mild alkalies at moderate temperatures. Technical info.

338 Piping, plastic. Bulletin Section PP from Goodall Rubber gives info on applications of flexible polyethylene piping. Many tables.

339 Pulverizer. Bulletin 51C-1 from Pulverizing Machinery Div., Metals Disintegrating, describes the "Mikro-Bud" vertical pulverizer with variable-speed classifier.

340 Pumps, centrifugal. Available in steel, brass, Monel, stainless, custom-built in titanium, tantalum, zirconium. Data from R. S. Corcoran.

341 Pumps, chemical. Bulletin from Dean Brothers Pumps describes its new "pH" chemical pump, available in 28 pump sizes, 14 corrosion-resistant alloys.

342 Pumps, gear, rotary. Bulletin 42 from Northern Ordnance gives design features, dimensions, capacities, horsepower, pressures.

343 Pump, hydraulic, high-pressure. Flow rates from 2 to 30 gpm. temperatures to 1,000°F. Up to ten stages. Data from Turbocraft.

continued on page 110

MATERIALS *from page 108*

ite 159," liquid epoxy resin composed primarily of resorcinol digylcidyl ether.

376 Surface Active Agents. Bulletin from Swift & Co. gives chemical and application specifications for more than ten synthetic surface active agents and industrial detergents.

377 Surfactants. New 44-page Booklet from Union Carbide Chemicals gives data on 8 nonionic, 4 anionic types. Selection, solubilities, properties, formulations, applications, performance, specifications, test methods.

378 Teflon. Bulletin from Du Pont, Polychemicals Dept., describes applications of Teflon sheets, rods, tubes, tape, other standard shapes.

One of a series

The revealing face of an iron crystal

A single crystal is an ideal system for studying the solid state. Physicists at the General Motors Research Laboratories have turned to whisker-like growths of nearly perfect single iron crystals to investigate three intriguing phenomena: magnetic domains, dislocation defects, and—more recently—high temperature oxidation.

In this latest study, the two crystallographically different surfaces found on iron whiskers are being used to examine the anisotropy or axial-dependent nature of the oxidation process.
In early stages of oxidation, the oxide patterns that form on clean surfaces have been found to be strongly dependent upon the orientation of the underlying crystal. In later stages of oxidation, tiny oxide "cilia" actually grow on the surface of the iron whisker.
But these new whiskery forms of oxidation are no longer related to the crystal's surface arrangement. The next step in this program involves correlating the oxidation behavior with lattice structure defects such as vacancies and dislocations.

This type of solid state research is revealing the atomic processes underlying strength, magnetic characteristics, and corrosion resistance of metals. At GM Research, we believe the solution to practical problems is increasingly dependent on fundamental information such as this. And each solution enables us to continue to provide "More and better things for more people."

GENERAL MOTORS RESEARCH LABORATORIES

Early Oxidation
(750x)

Oxide Whiskers
(12,000x)

Reduction of Oxide Products
(2500x)

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 108*

344 Pumps, rubber-lined. Brochure 557 from Allen-Sherman-Hoff Pump gives engineering data, applications.

345 Refractometer, process. For measurement and control of liquid organic and inorganic streams. Bulletin 0714-4 from Mine Safety Appliances.

346 Regulators, solenoid-actuated. For remote shut-off, remote start-up, automatic safety shut-off, combination pressure and temperature control. Data from OPW-Jordan.

347 Rotameters. Bulletin M-1 from Schutte and Koerting describes complete line of rotameters and flow indicators.

348 Screens, vibrating. Catalog Section from Syntron gives details of mechanical conveyor screens, designed for scalping and for coarse and medium sizing of bulk materials.

349 Seals, liquid, high-temperature. For sealing fractionating trays in all types of process equipment to temperatures up to 900°F. In 12 different types, with Monel, stainless, or Inconel wire binder. Info from Metal Textile Corp.

350 Separators, centrifugal. New 8-page Bulletin from Centrico gives details of special designs for purification, dehydration of oils and fats.

351 Separators, centrifugal, self-opening. For continuous processing of liquid mixtures with high solids content. Bulletin S.A1129-8-59 from De Laval Separator.

352 Size Reduction Equipment. Memo-Index from Gruendler Crusher & Pulverizer makes possible determination of proper machinery for reduction of more than 200 kinds of materials.

353 Strainers, high-pressure. Data Sheet 8310 from Spraying Systems details new line of stainless strainers for high-pressure lines. For ¼, ⅜, ½ in. pipe lines, choice of 4 mesh sizes.

354 Tanks, aluminum. Brochure from Reynolds Aluminum on advantages of aluminum tanks and vessels.

355 Tank Covers, plastic. Bulletin 59HC from Hammond Iron Works describes newly-developed "Hammondflote Cover", of rigid urethane foam, designed to reduce evaporation losses from vented tanks used for storing volatile liquids.

356 Television, industrial, closed-circuit. Bulletin from General Precision Laboratory describes basic cameras, accessories.

357 Thermocouple Wells. Catalog G102-1 from Minneapolis-Honeywell Regulator gives designs and dimensions, pressure and temperature ratings, corrosion data, ordering and price info.

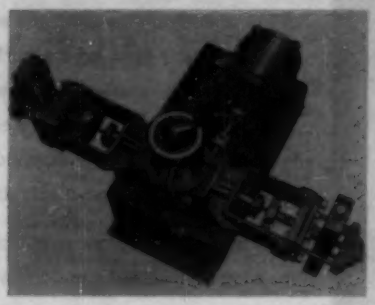
358 Tubes, corrosion resistant. Bulletin from Bridgeport Brass details tubes in aluminum, brass, copper, special metals for heat exchangers, condensers, distillation equipment, other processing requirements.

359 Tubing, corrosion-resistant. New Bulletin from Carpenter Steel gives technical data on tubing and pipe made of Hastelloy Alloy B and C. Table gives resistance to many corrosive fluids.

360 Valves. Ohio Injector offers "Buyers Guide" which cross-indexes complete OIC line of valves with valves of 16 other major makers. Abbreviations, valve trim chart, complete figure number specifications.

361 Valves, butterfly. New 4-page Condensed Bulletin from Continental Equipment, Division of Fisher Governor. 8 designs in sizes from 1 to 108 in., pressure drops to 1,200 psi, temp. to 2,000°F.

DEVELOPMENT OF THE MONTH



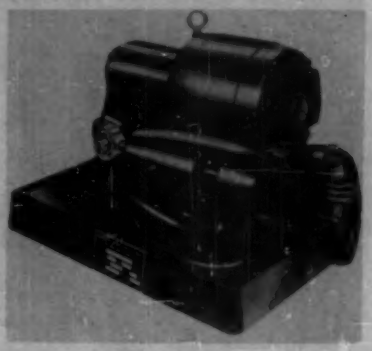
HEAVY DUTY METERING PUMPS (Circle 603 on Data Post Card)

Wallace & Tiernan introduces the Series 200 Metering Pump, an electrically-driven, positive-displacement, reciprocating, plunger-type pump. Capacities range from 0.65 to 2,025 gal./hour. Standard models operate against pressures up to 4,000 psi, with a metering accuracy within plus or minus 1%. Heavy-duty liquid ends are available for higher pressures.

Separate pumps—drive units and their liquid ends—may be ganged and driven by one motor. This arrangement gives increased capacity or allows multiple discharges for proportioning operations. Liquid ends, available in many materials of construction, are easily changed on the job to give different capacities or resistance to the corrosive action of different liquids.

For Bulletin from Wallace & Tiernan with all technical details, Circle 603 on Data Post Card.

DEVELOPMENT OF THE MONTH



NEW CONTROLLED-CAPACITY PUMPS (Circle 607 on Data Post Card).

A new series of controlled-capacity pumps is offered by American Meter. 200 Series Simplex pumps have a capacity of 812, while the Duplex model has double that capacity. Maximum pressure is 10,000 lb./sq. in.

Liquid ends made of various alloys are easily interchangeable in the field. It is not necessary to disconnect piping to clean or inspect valves.

For complete details, Circle 607 on Data Post Card.

362 Valves, control. Graver Water Conditioning offers single control valve for directing flow of liquids in zeolite softeners, ion exchange units, filters. Technical data.

353 Valves, control, air-operated. Bulletin 117 from Uniflow Valve gives dimensions, flow formulas for split-body design control valves.

364 Valves, high-pressure. Catalog 659 from High Pressure Equipment details valves and fittings for 30,000 and 60,000 psi service.

365 Viscometers. Bulletin 19 from Cannon Instrument. Technical details, selection data.

366 Viscometer, recording. Bulletin from Brookfield Engineering Laboratories gives details of the "Viscometran," for continuous indication, recording, control of viscosity under process conditions.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 600 on Data Post Card.

Tires that last ten years . . .
Foods that don't need refrigeration . . .
Tougher plastics . . .
these products of the future are subjects for experimentation today. Many industries and research institutions are now looking to cobalt 60 gamma irradiation as the key to new horizons.
Gammacell 220

Photo courtesy Textile Research Center, School of Textiles, North Carolina State College, Raleigh, N.C.

For your gamma irradiation experiments, choose the GAMMACELL 220

with source strengths to suit your purpose

IT'S PROVEN — Already in use in several countries and in many fields of research.

IT'S SELF-CONTAINED — No auxiliary shielding required . . . Buy it as just another piece of laboratory equipment. Easy to move to a new location as a change in plans requires.

IT'S SAFE — By construction, it is inherently safe to operate. Overexposure would have to be deliberately planned.

IT'S SIMPLE — No complex electrical equipment to break down. Any technician can readily operate it with minimum instruction.

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COMMERCIAL PRODUCTS DIVISION

P.O. BOX 93 OTTAWA, CANADA 59-1

For more information, turn to Data Service card, circle No. 52

institutional news

A.I.Ch.E. fund raisers honored as UEC drive continues

Leaders of 100%-plus local section Engineering Building Fund Drive tell some of the secrets of their notable successes.

Anderson

Boehm

Boyne

Blum

Eilinger

Frank

While ground has been broken for the new United Engineering Center in New York, the drive for needed funds continues. A.I.Ch.E. was the first of the five founder societies to subscribe its full quota. But while many local sections have reached or gone beyond their individual goals, some have not yet reached the needed 100%. If the new home of the profession is to be completed on schedule, the drive must continue. The only way A.I.Ch.E. can maintain its outstanding record is for all local sections to fill their quotas quickly.

Reports from the sections that are fully subscribed for the building fund show that each found its own path to success. One section reports that personal contact was essential, while another tells us that substantial contributions were solicited and received by mail. One campaign committee scaled down the suggested amount of money, another solicited non-members. One section used fund raisers with experience, another found that *enthusiasm* was the great factor. St. Louis, which hit 182% of the quota, exceeding 100% on the tenth day of the campaign, used a payroll deduction plan. Average pledge, with this method, was more than twice the amount received when solicited in the usual way. All sections, however, agree on one thing—the importance of organization and follow-up, and the ability of the solicitor to explain the cause for which the money was being raised.

The campaign committees, captains and workers in each local section,

NEW IR EJECTORS

Cut Vacuum Costs

New Series M Steam Jet Ejectors, with rugged, two-piece construction, offer big savings for general vacuum service

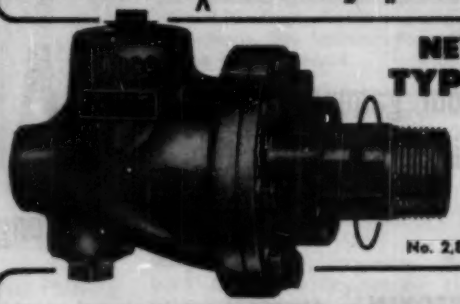
FOR CREATING vacuums, there is nothing simpler or more reliable than the new Ingersoll-Rand Series M ejectors. Designed to operate with 75 to 200 psig steam, they can handle either dry or wet gases and can be used for priming pumps and other hydraulic equipment. The low-cost Series M line includes 1½", 2" and 3" sizes with threaded connections and 4" size with flanged suction and discharge. For full details, send for new Bulletin No. 9046.

Ingersoll-Rand

4-916 ♥ 11 Broadway, New York 4, N.Y.

For more information, turn to Data Service card, circle No. 53

Need a Better rotary joint?



-It's BARCO!

For countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had—*and for LESS COST!*

"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. Minimizes corrosion, friction, wear. Stainless steel spring also standard.

RESISTS SEAL RING BREAKAGE—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.

WIDE SPACED BEARINGS—Two, instead of one . . . increased bearing area. No lubrication required. Lowest friction.

200 P. S. I. STEAM RATING—Heavy duty service at *no extra cost.* Eight sizes, ½" to 3". *Send for new Catalog 310 today.* BARCO MANUFACTURING CO., 560N Hough Street, Barrington, Illinois.

For more information, turn to Data Service card, circle No. 32

and all section members who were active, are to be commended for their hard work, determination and loyalty to the organization. But the campaign chairman and co-chairmen in the sections that have hit 100% are deserving of special recognition.

Here are the people who did it: **Douglas W. Anderson**, secretary, Detroit Section, is manager, General Pharmaceutical Department, Parke Davis. (110%)

Elmer L. Boehm, 1958 chairman of the Southwest Louisiana Section. A newcomer to Monsanto, Boehm was for ten years with W. R. Grace as project engineer. (199%)

W. J. Boyne, New Orleans Section, is senior process engineer at American Cyanamid's New Orleans acrylonitrile plant. (100%)

George W. Blum, Akron Section, is assistant manager of chemical engineering at Goodyear Tire, Akron. An educator, he once taught at Case. (111%)

William Eilinger has held just about every top office in the Rochester Section. He is technical associate, chemical manufacturing division, Eastman Kodak. (145%)

Harris

Johnson

Kernan

Kilmer

Leucht

Lippa

Pocket Size—Loose Leaf

LEFAX

TECHNICAL DATA BOOKS

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Printed on loose leaf, six hole, 6¾" x 3¾" bond paper, each book contains about 140 pages of technical data, condensed, accurate, essential material for engineer, technical worker, teacher, student and business man.

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Home Heating
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Electrician's Data
Builder's Data
Lumber Data
Air Conditioning
Bldg. Construction
Reinforced Concrete
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Surveying Tables
Highway Eng.
General Math
Math Tables
Physics
Trig-Log Tables
Gen'l Chemistry
Chemical Tables
Anal. Chemistry
Mechanical Drawing
Machine Design
Machinist's Data
Mech. of Materials
Power Trans. Mech.
Thermodynamic Tables & Charts
Phys. & Thermo. Data
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Metallurgy
Hydraulics
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Television & FM
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AC Motors & Gens.
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CHEMICAL TABLES HANDBOOK—320 pages of up-to-date complement of chemical tables covering the physical and thermodynamic properties of inorganic and organic compounds. Classified, indexed, loose leaf, pocket size in simulated leather cover. $4.

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FLOW METERS

FLOW INDICATORS

ROTAMETERS (for measuring fluid rate of flow): General Purpose, Glass Tube; Armored; Bypass and "T" types for large flows; Transmitting for remote indicating, recording, or controlling rate of flow; Laboratory; Chemical; Alarm; and Purge.

FLOW INDICATORS (for visual observation of fluid flow): Flapper; Rotary; and Ball Flow.

New BULLETIN 18L gives complete details on SK Laboratory Rotameters for measuring fluid rate of flow in glass, plastic, and temporary metal piping. Write for a copy.

Schutte and Koerting COMPANY

INSTRUMENT DIVISION

224 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

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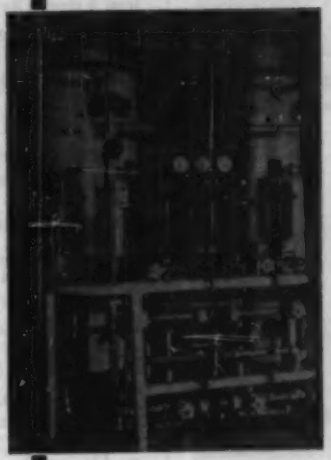

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Institutional news

from page 113

W. S. Frank, Northeastern New York, is manager, process development unit, at GE's Waterford Silicone Products Department. (157%)

Leonard A. Harris is chairman-elect, Akron Section. He is production superintendent at Columbia-Southern Chemical (Pittsburgh Plate Glass).

Robert C. Johnson, Twin City Section, is supervisor of process engineers, at Minnesota Mining's Commercial Chemicals Division in Minneapolis. (118%)

J. R. Kernan, Charleston (W. Va.) Section, chairman of the group in 1954-5, was coordinator of the section fund campaign. He is with Union Carbide Chemicals as production area supervisor. (133%)

J. W. Kilmer, Tulsa Section, has been section chairman and vice chairman. He is with Pan American Petroleum, Tulsa. (100%)

W. J. Leisten chairman of the Detroit Section, is with Wyandotte Chemicals.

Warren L. Leucht, Syracuse Section, is with Solvay Process Division, Allied Chemical. (101%)

Shepperd Lippa, New Haven Section, is manager, process engineering, B. F. Goodrich sponge products division, Shelton, Connecticut. (123%)

R. H. Morrison, Jr., a past chairman of the East Tennessee Section, has been with Tennessee Eastman, for 21 years. He is superintendent Cellulose Esters Division, Kingsport. (190%)

K. H. Pettengill, Ohio Valley Section, is head of the Synthetic Products Department at Arnold Hoffman & Co. Pettengill has held several offices in the section. (115%)

Fred Pfeiffer, chairman, Southern Nevada Section, is with the Henderson plant of American Potash and Chemical. (316%)

A. M. Platt, Columbia Valley Section, was head of the group last year. He is with the Hanford Atomic Products Operation, Richland, Washington, as supervisor of chemical engineering development. (116%)

Saul Ricklin, Rhode Island Section, is vice president in charge of development, Dixon Corporation, Bristol, R.I. Ricklin is former owner of Ricklin Research Associates. (100%)

Ralph Strigle, Jr. Akron Section, is vice president, Akron Sand Blast & Metallizing Company.

Charles W. Swartout, St. Louis Section, is operations manager, Mallinckrodt Chemical Works. While development engineer at Linde Air Products, he was responsible for several patents. (182%)

Morrison

Pettengill

Pfeiffer

Platt

Ricklin

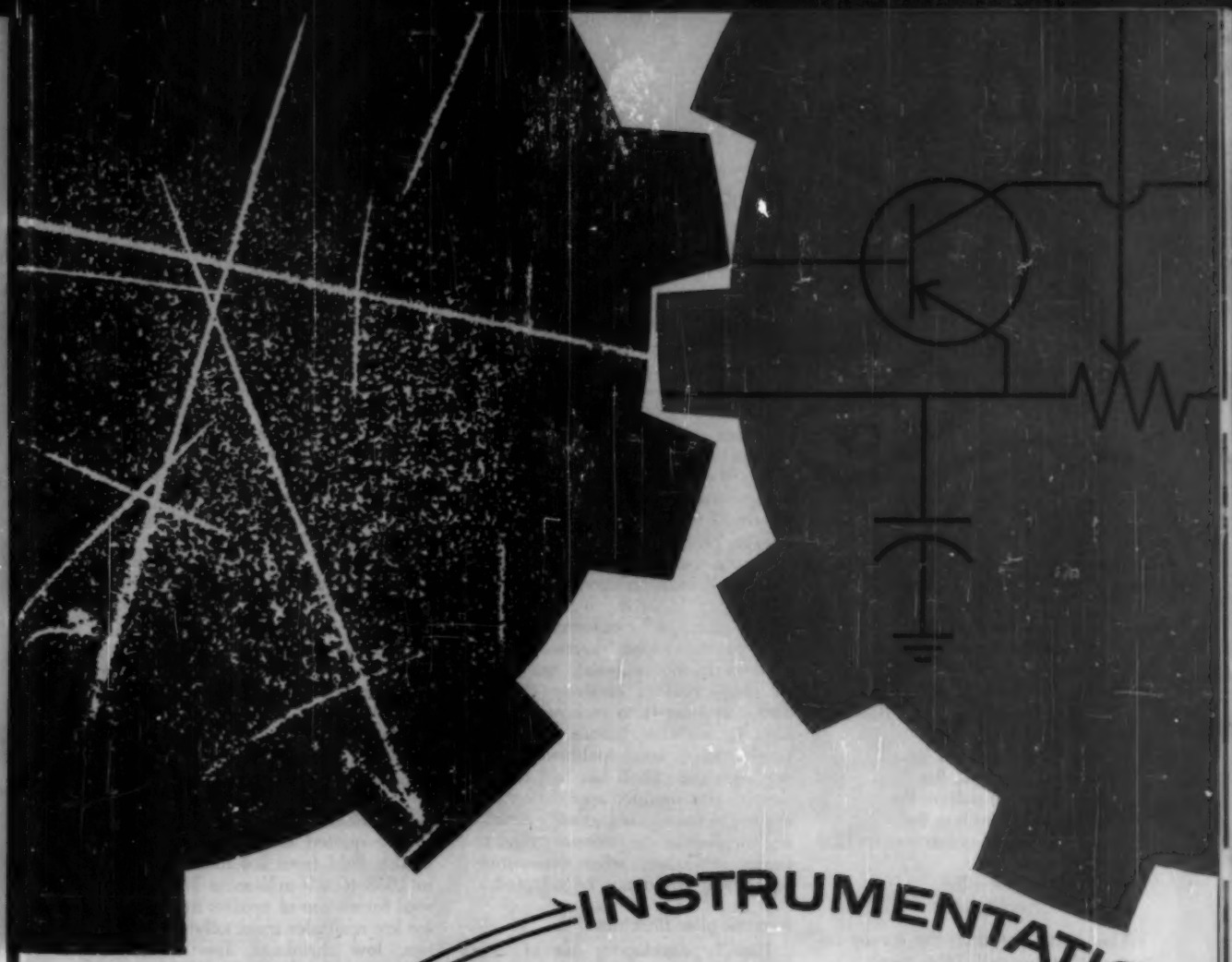
Strigle

Swartout

Woodfield

F. W. Woodfield, Columbia Valley, is co-chairman of the section. He is with General Electric at Richland, Washington. Woodfield also served for several years as a chemical engineer with Du Pont. He is a former chairman of the section.

Two more sections, not pictured here, went over the 100% mark in the drive. Great Salt Lake Section did it under the leadership of L. E. Thatcher, and Indianapolis Section made the goal with R. G. Weldele showing the way.



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chemical feature

Epoxies—for the tough jobs

No glamor applications, but wide range of uses demanding superlative heat, corrosion, and temperature resistance should assure stable growth rate.

FROM AN ESTIMATED 21.2 million pounds per year in 1958, use of epoxy resins for protective coatings, their biggest single application, should grow to about 48.4 million pounds per year by 1963, according to a market survey made recently by a group at the Harvard Graduate School of Business Administration. Total consumption, about 29 million pounds in 1958, is predicted to reach 88.1 million pounds in 1963.

According to the Harvard survey, 1963 consumption will break down as follows:

Electrical—8.9 million lbs.
Tooling—6.2 million lbs.
Laminating—3.9 million lbs.
Adhesives—3.7 million lbs.
Roads, flooring, construction—12.0 million lbs.
Boats—2.0 million lbs.
Piping—3.0 million lbs.

This is compared in the survey report with estimated 1958 uses:

Electrical—2.4 million lbs.
Tooling—2.5 million lbs.
Laminating—1.3 million lbs.
Adhesives—1.2 million lbs.
Other—0.4 million lbs.

No royal road

Skid-resistant road surfaces would seem to offer a large volume sales outlet for epoxies. Epoxy road coatings, a joint development of Shell Chemical and Reliance Steel, offer many evident advantages:

- Good traction even under oily or wet road conditions;
- Excellent wearing properties;
- Good resistance to extremes of hot or cold;
- Light weight;
- Fast curing.

Road tests have been underway for eight or ten years, results have been excellent. One test, in particular, at the Milford Toll Station of the Wilbur Cross Parkway, in Connecticut, is said to have reduced skidding accidents to zero at an especially dangerous point on the highway.

Properly applied, it is claimed that the bond between the epoxy resin and the road surface is so good that any break will occur in the pavement rather than at the interface.

However, according to a Shell Chemical engineer who has been deeply involved in the development program, we cannot expect that all roads will soon be epoxy-coated as if by magic. Main fly in the ointment is not, as might be expected, the high cost of the resins themselves as a road surfacing material, but rather, the high cost of cleaning the road and preparing it to receive the coating. In addition, before offering the proposition to municipalities and highway agencies, Shell has had to delve deeply into product application techniques, in some cases actually developing themselves the necessary road surfacing machinery when conventional equipment could not be adapted.

Automobile finishes

Rapidly developing use of epoxy resin coatings is on Detroit assembly lines. Chrysler, Ford, General Motors, Studebaker—are all currently using epoxy priming coats (usually several) followed, in general, by a high melamine enamel. American Motors goes so far as to dip the whole auto frame in epoxy primer, to insure complete rust protection.

New spray technique

Revealed at the recent Atlantic City conclave of the National Paint, Varnish and Lacquer Association and the Federation of Paint and Varnish Production Clubs, was a new Shell Chemical system for using ordinary spraying equipment to handle a 100% epoxy coating. Using two new curing agents, Epons H-1 and H-2, Shell says that single coats can now be applied with thicknesses up to about ten mils. Also at Atlantic City, Union Carbide unveiled two new epoxies claimed to be particularly adapted for use in fluidized-bed coatings.

The Shell Chemical technique depends on use of a special spray gun. The two materials, resin and curing agent, are pressurized separately and delivered to the gun in different lines. Nothing is left to the operator. An electrical proportioning system insures that the correct mixture is sprayed on the surface. Curing time is said to be from 48 to 72 hours.

In fluidized-bed coating, the object to be coated is preheated and then immersed in the fluidized bed, causing fusion of the resin particles on the surface. During a subsequent baking procedure, the separate particles flow together to form a homogeneous unified coating.

Electrical embedments

Aside from coatings, biggest potential for epoxies is probably in potting of electrical components—the Harvard survey quoted above predicts a rise in this field from 2.4 million pounds in 1958 to 8.9 million in 1963. Reasons for choice of epoxies in this service are multiple: good adhesive qualities, low shrinkage, low insulation resistance, good chemical and moisture resistance, low curing temperature, long life. Of commercially available materials, only the isocyanate resins, it is claimed, approach the epoxies for use in electrical encapsulation.

Stabilizing influence

Peracetic acid-derived epoxies have become essential in the compounding of the vinyl resins. For example, a typical formulation will contain from 5 to 10 parts of epoxy to 100 parts of polyvinyl chloride. Since production of vinyl resins may soon top 1 billion pounds per year, the future for epoxies as stabilizers seems assured.

Slow but sure

The epoxies are no glamour girls. They are, rather, the workhorses of the chemical industry, to be investigated wherever high corrosion and temperature resistance and long life are more interesting than price per pound. Look, therefore, for a comparatively slow but steady rise in volume—8 to 10% per year might be a reasonable estimate.

For more information, circle No. 39 ▶

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future meetings

1960—MEETINGS—A.I.Ch.E.

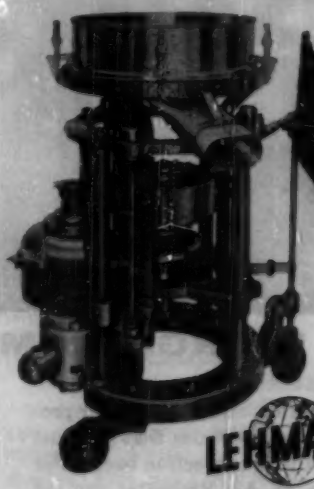
• **Atlanta, Ga., Feb. 21-24, 1960. Hotel Atlanta Biltmore. A.I.Ch.E. National Meeting.** Technical program Chairman: P. Bellinger, Georgia Tech. 225 North Avenue, N. W. Atlanta 13, Ga. **Student Program:** H. C. Lewis, School of Ch.E., Georgia Tech., Atlanta 13, Ga. **Kinetics**—C. D. Holland, Ch.E. Dept. Texas A&M. College Sta., Tex. **Pesticides** (2 sessions). D. J. Porter, Diamond Alkali, Box 348, Painesville, Ohio; **Nuclear Feed Materials Processing**—D. S. Arnold, American Potash & Chemicals Co. Henderson, Nev. **The Textile Industry**—J. E. Warren. Chem. Div., Goodyear Tire & Rubber Co. Akron 16, Ohio. **High Temperature-Pressure Technology**—H. R. Batchelder, Battelle Memorial Inst. 505 King Ave., Columbus 1, Ohio. **Mass Transfer Applications in Waste Treatment** — W. W. Eckenfelder, Manhattan College, Riverdale, N. Y. 71, N. Y. **Filtration**—F. M. Tiller, Dean Coll. of Eng., U. of Houston, Houston 4, Tex.; **Mineral Engineering**—W. A. Koehler, W. Virginia U., Morgantown, W. Va. **Bioengineering**—M. R. Sfat, Rahr Malting Co., Manitowoc, Wis. **Missiles & Rockets**—R. B. Filbert, Jr., Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio. **Selected Papers** (5 sessions) **Air Pollution, Energy, Education, Fluids, Management, Petroleum-Solvents** themes)—R. J. Kyle, Eng. Exp. Sta., Georgia Tech. Atlanta 13, Ga.

• **Mexico City, Mex. June 19-22, 1960. Hotel Del Prado. A.I.Ch.E. National Meeting**—Tech. Prog. Chmn.: O. E. Montes, Northern Nat. Gas Co., 2223 Dodge St., Omaha 1, Nebr. **Petroleum & Natural Gas Processing in Latin America**—F. W. Jessen, Petrol. Eng. Dept., U. of Texas, Austin, Tex. & P. Cornero. Ref. Madero, Tampa, Mex. **Chem. Engineering in Latin America**—G. Mayurnik, W. R. Grace, 3 Hanover Sq., New York 4, N. Y. & S. Vazan, Chem. Constr. Corp., 525 W. 43 St., New York 36, N.Y. **Chemical Engineering Education in the Americas**—W. R. Marshall, Jr., Dean, U. of Wisconsin, Madison 6, Wisc. & P. O. Roel, Inst Tec. y de Estudios Sup. Sucursal de Cerros J., Monterey, Nuevo Leon. **Machine Computation-Optimization, Pitfalls, and Potentials**—W. M. Carlson, Louviers Bldg., Dupont, Wilmington 98, Del. **Food and Biochemicals**—M. Ibarra, Comp. Destiladora, Pl. San Lazaro #21, Mex., D. F. **Distillation Equipment**—R. Katzen, 3732 Dogwood, Lane, Cincinnati, O. & F. Ocampo, PEMEX, Vallarta #7-4° Piso, Mex., D. F. **Minerals and Metals**—D. B. Coghlan, Foote Mineral Co., Box 574, Berwyn, Pa. **Transfer Processes in Two-Phase Systems**—S. G. Bankoff, Ch.E. Dept., Northwestern U., Evanston, Ill. & A. Hoyos, Xola #1284-3° Piso, Mex., D. F. **Construction and Operating Costs for Latin American Projects**—R. Voorhees, Union Carbide Dev. Co., 30 E. 42 St., N. Y. 17, N. Y. & R. Pardo, Dir. Bufete Ind., Insurgentes sur 132-102, Mex., D. F. **Laboratory and Pilot Plant Techniques**—J. T. Cumming, Penn College, Cleveland 15.0, & M. Puebla, Inst. Mex de Invest. Tec., Calzada Lezaria #694, Mex., D. F. **Cryogenic Engineering**—F. Kurata, Ch.E. Dept., U. of Kansas, Lawrence, Kan. **Selected Papers**—(Mex.) C. Baptista, PEMEX, Vallarta #7-4° Piso, Mex., D. F. **Selected Papers**—(U.S.A.) J. A. Samaniego, Shell Dev. Co., Emeryville 3, Calif. & S. S. Menache, Calderone de la Barca #417, Mex., D. F. **Financing International Projects**—P. F. Genachte, Chase-Manhattan Bank, New York, N. Y. & J. Horcasitas, Credito Bursatil, Isabel la Catolica #38, Mex., D. F. **Student Program**—J. J. McKetta, Ch.E. Dept., U. of Texas, Austin, Tex.

Deadline for papers January 19, 1960.

• **Moscow, USSR, June, 1960, 1st Congress of International Fed., Automatic Control. To cover areas of Theory, Hardware & Applications of Automatic Control, U. S. participation** sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prodn., Des Plaines, Ill. For attendance & deadline info write: Secy., W. E. Vannah "Control Engrs.", 330 W. 42 St. N. Y. 36, N. Y.

• **Buffalo, N. Y., Aug. 14-17, 1960. Statler Hilton Hotel 4th National Heat Transfer Conference & Exhibit.** Sponsored by **A.I.Ch.E. & ASME.** A.I.Ch.E. papers to S. W. Churchill, U. of Mich., Ann Arbor, Mich. **ASME** papers to J. P. Hartnett, U. of Minnesota, Minneapolis.



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CW/105

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Minn. Exhibit info to P. A. Jeculver, A.I.Ch.E., 25 West 45 St., N. Y. 36, N. Y.

● Tulsa, Okla., Sept. 25-28, 1960. Hotel Mayo. A.I.Ch.E. National Meeting. Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co. Bartlesville, Okla. Multiphase Flow in the Production & Drilling of Oil Wells—L. P. Wharton, Atlantic Refining, Box 2819, Dallas 1, Texas. Natural Gas & Natural Gas Liquids—R. L. Huntington, U. of Oklahoma, Norman, Okla. Advances in Refinery Technology—W. C. Offutt, Gulf R&D Co., P. O. Drawer 2038, Pittsburgh 30, Pa. Petrochemicals—C. V. Foster, Continental Oil Co., Ponca City, Okla. & K. L. Hays, Phillips Chem. Co., Bartlesville, Okla. Piloting, or Why Buy the Restaurant When All You Need is a Meal—R. E. Wells, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. Corrosion & Materials of Construction—W. A. Luce, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Worley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. Statistics and Numerical Methods Applied to Engineering—R. L. Heiny, 2700 Jefferson, Midland, Mich. Air & Ammonia Plant Safety—O. Weigers, Cyanamid. Refinery & Natural Gasoline Plant Safety—J. W. Romine, Phillips Petrol., Bartlesville, Okla. Processing Agricultural Products—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M Coll. Sta., Tex. Chemical Reactions Induced or Modified by Radiation—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor, Mich. Conservation & Utilization of Water—F. J. Lockhart, Ch.E. Dept., U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. Foams—C. S. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Rsch. Lab., Wash. 25, D.C. Computers as a Management Tool—R. Ozmer, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. Non-Newtonian Fluid Mechanics—A. B. Metzner, U. of Delaware, Newark, Del. Student Program. Selected Papers—R. H. Perry, Ch.E. Dept., U. of Oklahoma, Norman, Okla.

Deadline for papers: May 2, 1960.

● Washington, D.C. Dec. 4-7, 1960. Statler Hotel. A.I.Ch.E. Annual Meeting. Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va. Tentative program framework: Chemical Engineering in Govt. Programs. Agency oriented: Chemical Warfare-Toxic Plant Construction; Chemical Warfare-Dispersal of Material in Aerosol Form; Servicing the Foot Soldier; Agriculture: Chemical Engineering-A Vital Link in Broadening Uses of Agricultural Crops; Chemical Engineering in Public Health Programs; Land Warfare Technology; Process Engineering in Propellants; Soils Stabilization; Foreign Assistance Programs; Saline Water; Govt. Administration of Basic Research. Subject oriented: Air Pollution; Computer Control of Chemical Processes; Fluid Dynamics; Instrumentation for the Unsteady State; Phase Transitions; Selling Abroad; Effects of Govt. Programs on Ch.E. Education; Financing in Govt. Contracts; Engineer as an Interpreter of American Culture; Nuclear Reactor Operations.

Deadline for papers: July 5, 1960.

1961—MEETINGS—A.I.Ch.E.

● New Orleans, La. Feb. 26-Mar. 1, 1961. Hotel Roosevelt. A.I.Ch.E. National Meeting. Tech. Prog. Chmn.: H. L. Malakoff, Petroleum Chem. P.O. Box 6, New Orleans 6, La. Kinetics of Catalytic Reaction; Brainstorming Technical Problems; Petrochemicals—Future of the Industry on Gulf Coast; Centrifugation; Future Processing Technologies in the Petroleum Industry; Education and Professionalism; Mathematics in Chemical Engineering; Evaluation of R&D Projects; Liquid—Liquid Extractions; New Processes in the Area; Water from Sea Water; Materials of Construction; Flow Through Porous Media.

Deadline for papers: Sept. 5, 1960.

● Cleveland, O., May 7-10, 1961. Sheraton-Cleveland. A.I.Ch.E. National Meeting. Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 10, O. Management Criteria for Capital Investment; Technical Phases of the Synthesis of Isoprene; Process Development of the New Synthetic Rubbers; Use of Radioactive Materials for Chemical Process Control; Modernized Process for Heavy Chemical Manufacture; Optimum Utilization of Pilot Plant Facilities; Petrochemicals as The Starting Materials for High Polymers; Chemical Engineering and Metal Refining; Fluid Mechanics; Applications of Photography in Chemical Engineering.

Deadline for papers: Dec. 7, 1960.

● Lake Placid, N. Y. Sept. 24-27, 1961. Lake Placid Club. A.I.Ch.E. National Meeting. Tech. Prog. Chmn.: E. R. Gmoley, Lummus, 385 Madison Ave., New York 17, N. Y. Process Management; Commercial Chemical Development; Sales Engineering.

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To reduce the cost of marketing polystyrene pellets

Solution:

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A recent announcement by officials of Cosden Petroleum Corporation tells of a new delivery concept, called, "Curb-Service Marketing." The revolutionary marketing plan involves the delivery of polystyrene pellets by special highway transports.

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Sprout-Waldron bulk trucks are cutting handling and delivery costs in a variety of chemical applications. For more details, request Bulletin 205-A.

CW/104

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Size Reduction • Size Classification • Mixing
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A.I.Ch.E Candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 9 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before January 15, 1960, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

MEMBERS

Ahlness, R. L., *St. Paul, Minn.*
Berg, Dana E., *Elmwood Park, Ill.*
Burar, J. A., *Huntington Park, Calif.*
Cooke, Norman E., *Montreal, Que., Canada*
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Foresti, Ray, Jr., *Dayton, Ohio*
Genova, Maurice L., *Waverly, Ohio*
Gollo, Harold A., *Lincoln Park, N. J.*
Leach, Donald L., *Rochester, N. Y.*
Lord, H. A., *New York, N. Y.*
MacNaughton, William, *Kingsport, Tenn.*
McHarg, Robert E., *Overland Park, Kans.*
Morgen, Ralph A., Jr., *Oklahoma City, Okla.*
Orlvia, James D., Jr., *Rockville Centre, N. Y.*
Oldshue, James Y., *Rochester, N. Y.*
Raines, J. Walter, *Wilmington, Del.*
Roberts, William Allan, *Bronx, N. Y.*
Saxton, Harry B., Jr., *Belle, W. Va.*
Schneider, Henry, *Niagara Falls, N. Y.*
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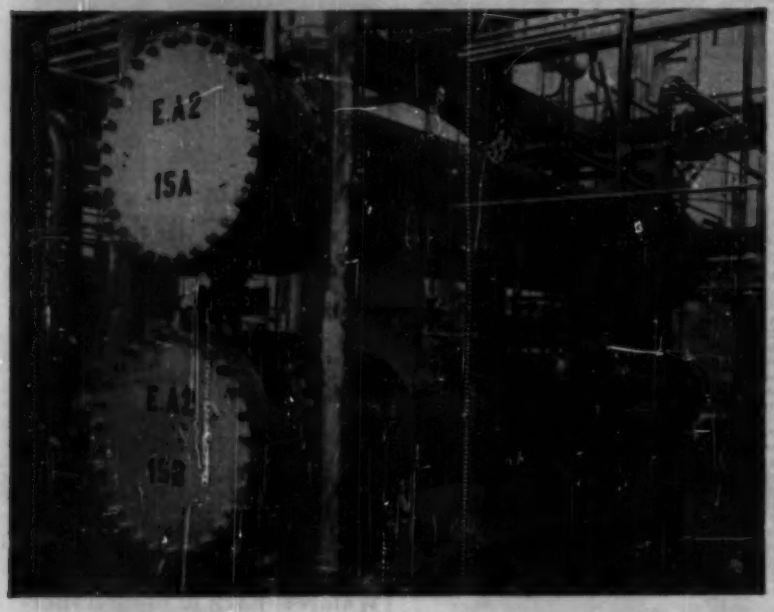

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U.S.I. CHEMICAL NEWS

Dec. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1959

Polyethylene Expansion To 300 Million Pounds Planned by U.S.I.

U.S.I. has recently announced plans for a new increase in production capacity of PETROTHENE® polyethylene resins at its Houston plant—this time 50 million pounds. This will bring total company capacity to 300 million pounds per year.

The Houston plant, opened just this past March, is already being upped from 75 to 150 million pounds and, with this new expansion, will reach a capacity of 200 million pounds annually. At its other plant in Tuscola, Illinois, the company is producing polyethylene at the yearly rate of 100 million pounds.

The new expansion, expected to be complete by mid-1960, will make U.S.I., with a capacity of 300 million pounds, the second largest polyethylene producer in the world.

Gas producing area at U.S.I.'s Houston plant.

New Inorganic Polymer Has Been Made from Zinc, Chlorine and Ammonia

Researchers have recently reported the development of a new polymer containing only zinc, chlorine and ammonia—which appears to have limited elastomeric properties. The development is significant since plastics and rubber-like materials are made for the most part from organic polymers. In general, inorganic substances do not form polymers, and cannot be produced in rubbery form.

Inorganic polymers are being investigated because many inorganics resist higher temperatures than do organics, and present operating temperatures for many devices are at about the limit that organic polymers can stand. Inorganic polymers might permit raising operating temperature limits.

The new material is called a polymeric monoaminedichlorozinc, and its thermal and hydrolytic stability are said to leave much to be desired. Consequently, the research group plans to make and evaluate a large number of such compounds, in the search for the specific properties of thermal stability and elastomeric nature desired.

The new product is described as an amber-colored, transparent, glassy material at room temperature. It softens on heating and becomes a heavy syrup at about the boiling point of water. When just molten, it can be drawn into fine filaments which are reported to exhibit plasticity and flexibility after cooling. Films of the polymer are said to adhere well to aluminum and glass surfaces.

Complete Details on Sodium-Handling Equipment Presented In New U.S.I. Brochure

Third Edition of Comprehensive Sodium Handling Book Contains Much New Data, Presents Latest Information on All Phases of Handling Technology

The third edition of U.S.I.'s brochure, "Handling Metallic Sodium on a Plant Scale", edited by U.S.I.'s experienced technical service engineers, is just off the press. This brochure has been an authoritative source of information since the first edition was published in 1951, shortly after U.S.I. first opened its sodium plant at Ashtabula, Ohio.

Revised and greatly expanded, the new edition contains the latest information on metallic sodium and its uses, sodium-handling equipment, procedures for handling sodium in the plant, and general safety and first aid measures. The list of references has been brought up-to-date.

Equipment Section Is Comprehensive

The equipment section in particular has been enlarged and is now more than two times its former size. It gives much more detail on construction of pipelines for handling sodium; heating of sodium-carrying lines and valves; insulation, repair and alteration of lines; recommended gaskets, valves and vessels for handling sodium; pumping, transferring, filtering and purifying of the liquid metal; and instrumentation of liquid sodium systems.

In this section, a table has been added giving typical data on induction heating of sodium pipelines. The table on power requirements for electrical resistance heating has

MORE

Research Elders Form Non-Profit Consulting Group

A novel kind of association has been formed under the name Technically Experienced Associates, Mobilized, or "TEAM, Inc." Members are retired research executives of some of the largest industrial companies in the country. They have formed this association to make their wide research experience available "for the benefit of mankind, without entering into competition with commercial consulting organizations or individuals."

"TEAM" members offer their services in these general research and advisory fields: research management, national defense, scientific and technical education, public health, conservation of human and natural resources, and scientific matters of national and international interest.

In keeping with the purposes and objectives of the organization, "TEAM" members offer their services at cost plus a small overhead to cover office expenses. The association says it will welcome as additional members retired research executives from broad fields of professional and scientific activity.

The cover remains the same, but the contents have been updated and greatly expanded in U.S.I.'s new edition of the brochure, "Handling Metallic Sodium on a Plant Scale."

Illustration from U.S.I.'s new sodium-handling brochure shows magnetic flowmeter in sodium line at Mallory-Sharon Metals' zirconium and titanium plant, Ashtabula, Ohio.

Dec. ★ **U.S.I. CHEMICAL NEWS** ★ 1959

CONTINUED

Sodium Book

been completely revised. Also up-dated and enlarged is the table of recommended hardware for piping systems.

Sources and Safety Stressed

The new edition emphasizes safety measures throughout the book, as well as in a special section devoted to the subject. Throughout the book, also, can be found plentiful mention of sources for equipment, offers of technical assistance on specific problems covered in the text, and many cross-references.

The number of figures illustrating the book —and this includes diagrams and photographs —has been increased by 50%. The additions consist largely of interesting new installation photos. To aid the reader, most diagrams have been enlarged and made more legible.

Copies of the third edition of "Handling Metallic Sodium on a Plant Scale" may be obtained from U.S.I. upon request.

Three New Appointments in U.S.I. Sales Divisions

BROOKS

PARKER

LONGSTRETH

Albert C. Brooks has been named Manager of the U.S.I. Baltimore Sales Division, succeeding James F. Whitescarver who retired this September. Mr. Brooks has been with U.S.I. for over a quarter century, in plant work, sales, and most recently as Assistant Sales Division Manager in Baltimore.

Roy A. Parker has been appointed Kansas City-St. Louis Division Manager for U.S.I. Mr. Parker has been associated with the company for about 33 years and, prior to his new assignment, was Manager of the Kansas City, Mo. Sales Office.

Joseph G. Longstreth has been made Manager of U.S.I.'s St. Louis Sales Office. He has been a sales representative for the company in the St. Louis area since he joined U.S.I. in 1955.

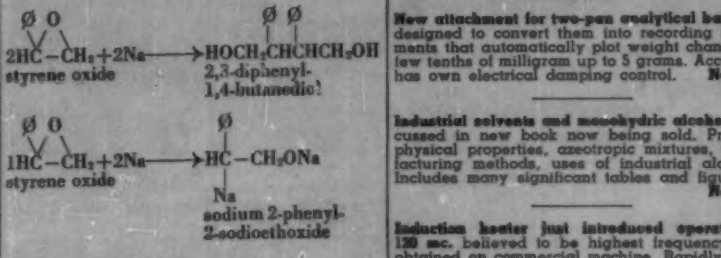
Reactions of Sodium and Compounds Discussed at Organometallic Symposium

At the Organometallic Chemistry Symposium, conducted as part of the 15th Southwest Regional Meeting of the ACS at Baton Rouge, La., on December 3, U.S.I. researchers contributed two papers on organosodium compounds.

In a paper entitled "Reactions of Disodiooctadienes," by Nobis, Robinson, Allgeier and Moormeier, it was indicated that the reaction of these compounds with oxygen or an oxygen-containing material such as an epoxide, aldehyde, ketone or chloromethyl ether, leads to a great variety of long-chain glycols. They are produced in high yield and contain eight to fourteen carbon atoms, depending on the reactant. Straight and branched chain compounds are present and easily separated.

Also covered in the paper was the ability of disodiooctadienes to metalate a variety of olefins and aromatics to yield other organosodium compounds such as allylsodium, butenylsodium, phenylsodium and benzylsodium, along with the mixed octadienes as by-products.

A paper entitled "Reactions of Sodium with Epoxides," by Madot and Robinson, revealed that such reactions result in a cleavage of the oxirane ring. The products are either 1,4-glycols (by dimerization) or a novel type of organosodium alkoxide, depending on the ratio of sodium present. For example:



These reactions are carried out with sodium dispersions in "active" ether solvent media at low temperatures. Other examples and some discussion of mechanism were presented.

Copies of either or both of these papers may be obtained from U.S.I. upon written request on company letterhead.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

New disposable polyethylene boots for technicians in biological and atomic laboratories, where spreading of contamination is a problem, are now on market. Made of lightweight film, boots give several hours of wear over shoes. **No. 1540**

Treatment of industrial foaming problems with silicones is described in new bulletin. Discusses causes of foaming, control methods, selection of proper defoamer, equipment, techniques for evaluating defoamer effectiveness. **No. 1541**

Expanded zirconium sheet can now be obtained in sheet thicknesses from .020" to .125" into ⅛" to 1½" diamonds, in standard sheet sizes, as unflattened or flattened mesh. Gives resistance against strong or hot phosphoric, hydrochloric, sulfuric acid solutions. **No. 1542**

New fire extinguishing system for small, hard-to-protect areas has been developed. Uses high pressure liquid CO_2 in easily stored cylinders. System can be installed in limited space in warehouses, industrial plants, laboratories. **No. 1543**

Rocket propellants are covered in detail in a new 224-page book now being sold. Contents include composition, production, performance for solid and liquid systems; burning, ignition, igniters; rockets using each type fuel; safety. **No. 1544**

New marking and decorating ink for treated or untreated polyethylene is now available. Said to remain permanently flexible and does not chip when flexed. **No. 1545**

New attachment for two-pan analytical balances designed to convert them into recording instruments that automatically plot weight changes of few tenths of milligram up to 5 grams. Accessory has own electrical damping control. **No. 1546**

Industrial solvents and monohydric alcohols discussed in new book now being sold. Presents physical properties, azeotropic mixtures, manufacturing methods, uses of industrial alcohols. Includes many significant tables and figures. **No. 1547**

Induction heater just introduced operates at 120 mc. believed to be highest frequency ever obtained on commercial machine. Rapidly heats highly resistive conductors. Acts as dielectric heater of nonconductors like polyethylene. **No. 1548**

Chemical marketing problems in the 1960s are forecast in a new book which can now be purchased. The volume consists of a collection of papers presented at the national meeting of the ACS in September, 1959. **No. 1549**

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■ A manual for a Line Sizing program, developed by the A. G. McKee Company, which was abstracted in the May, 1959, issue of C.E.P., is now on sale at the Secretary's office of the American Institute of Chemical Engineers for $30 a copy.

■ The program performs calculations necessary to convert the units of flow and density; to size liquid, vapor, or water lines on the basis of a specified maximum pressure drop; and to determine the pressure drop for a given diameter and length of pipe.

Other manuals, available during the first half of 1960, will cover heat exchanger design, multicomponent distillation calculations, and estimation of nonlinear equations to represent data.

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1959 Chem Show

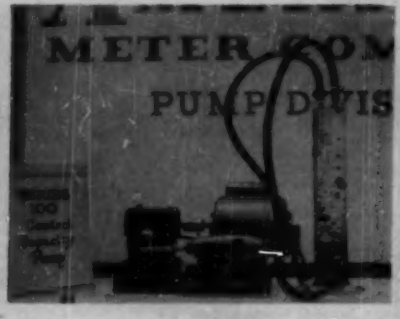
New York Coliseum
Nov. 30-Dec. 4

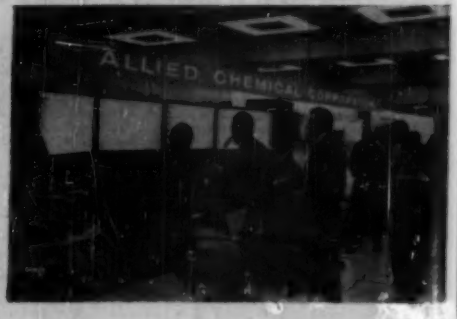
This year's giant Chem Show occupied all four floors of the Coliseum, exhibited and demonstrated something for every engineer from bags to complete plants. Here are some highlights.

Giant glass distillation column (15-ft. high, 100 liters) attracted attention at Corning Glass booth.

Sales manager J. Stewart (Simpson Mix-Muller Div., National Engineering Co.) shows company's wares.

Below: (l. to r.) Crowd at Dean Brothers booth; featured American Meter pump; another crowd learning Allied's story; just a part of Pfaudler Permutit's extensive equipment display.





cep camera

Ever-Tite Coupling's sales manager J. A. Buchanan demonstrates a new coupling for glass piping which requires no flanged joints. Coupling is so new the company is still preparing literature. Listener—D. Ross, Polaroid Corp.

Standard filter press was a feature of Niagara Filter Div., American Machine & Metals.

Above: (Top to bottom) Corrosion resistant packaged vacuum producer at Schutte and Koerting booth; filter aids at Great Lakes Carbon; demonstration by Galigher Co. of its air-operated and hand operated valves; model symbolizes Dorr-Oliver's worldwide activities.

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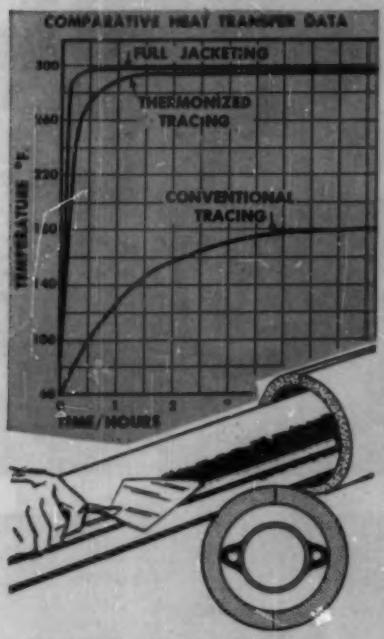

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local sections

South Texas sets attendance record

An all time record was set when over 1000 attended the 14th Annual Meeting of the **South Texas Section** (*J. B. Platz*) in Galveston on October 30. Highlighting the all day meeting was the Awards Banquet which honored four section members. The technical program included three symposia covering the widely separated fields of plastics-polymerization, instrumentation, and chemical manufacturing opportunities abroad. More than 50 exhibits displaying the latest in engineering equipment were on view at the Moody Convention Center, where the sessions were held.

Awards

William A. Cunningham, J. J. Cinque, V. J. Huang, J. R. Hodson, and Frank M. Tiller were award recipients. The newly established awards, two A.I.Ch.E. and two Section, are part of a continuing policy on the part of the Institute and the South Texas Section to recognize outstanding men and achievements in the chemical engineering profession.

Cunningham, a member of the chemical engineering department at the University of Texas, was a director of the Institute for 1955-57. He was cited for high technical competence, leadership in the engineering profession, and participation in A.I.Ch.E. activities. The Outstanding Young Member Award for service to the profession went to J. J. Cinque. Cinque is a group leader in process

continued on page 128

Award winners Tiller (r.) and Huang.

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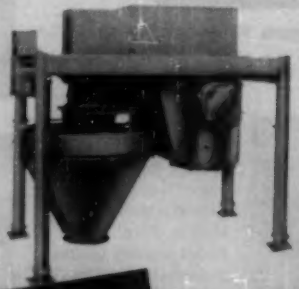

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The South Texas Section Award for Best Fundamental Publication was given to Frank Tiller for his article on *The Role of Porosity in Filtration*. Tiller, dean of engineering at the University of Houston, is well known for his work on this subject. This article was published in the *A.I.Ch.E. Journal* in 1958. His first two articles on the subject appeared in *CEP*, while another is in preparation.

V. J. Huang and J. R. Hodson received the Section Award for Best Applied Publication. Their paper, *Perforated Trays are Designed This Way*, appeared in *Petroleum Refiner*. Huang, a professor of chemical engineering at the University of Houston, is conducting a number of research projects at the University. Hodson, co-author, is head of process design and economics at Texas Butadiene and Chemical.

Technical Sessions

Attracting considerable interest on the 12-paper program was the discussion on chemical manufacturing abroad. Included were papers on chemical manufacturing by American companies in Brazil, Mexico, and the European Common Market.

In the specialized symposia on Instrumentation, a new method for the closure problem in calculation of multi-component distillation towers and related systems was presented to the meeting, by A. M. Peiser. This method, based on the concept of the tower as an extension of a single flash drum, leads to rapid convergence of successive values in all cases. A notable feature of the application of the method to design is that the selection of the optimum feed point location is based directly on the requirement of minimum size, rather than on conventional key matching criteria. The method has been in use on a digital computer for over a year, and has been applied to design and rating of several hundred towers.

Particularly timely was the panel on *Use of Nuclear Devices for Recovery of Thermal Energy*. H. G. Corneil and A. D. Suttle, Jr. Humble Oil, presented recently declassified AEC data in the use of nuclear devices in contained underground explosions which have been proposed for several uses of interest to the petroleum and chemical industries. Among these are the recovery of process heat, the generation of electric power, the breakage of oil shales to permit in situ processing. The salt dome is a logical geological structure for conducting the operations and recovering the liberated rock.

Chicago chemical industry

Sales of the Chicago area chemical and drug industries will amount to about $1-1½ billion in 1959, or approximately 6 percent of the total for the entire United States. The speaker, William F. Mitchell, considers the Chicago area the country's most important manufacturing center. He gave the **Chicago Section** (*R. L. Opila*) October meeting some general statistics on the Illinois Chemical Industry. According to Mitchell, who is general manager, chemical division, General Mills, in 1959 alone over $50 million will be spent by the local chemical industry on 19 major expansion projects. Specialty chemical products are an extremely important factor in the area industry.

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people in management and technology

The Award for Best Presentation of Paper at the recent A.I.Ch.E. meeting in Kansas City went to **R. Koeller.** He was selected for his presentation of *Diffusion in Compressed Binary Gaseous Systems* (scheduled to appear in the *A.I.Ch.E. Journal* in March).

Koeller is with Pan American Petroleum, Tulsa, Oklahoma. A technical group leader in the Research Department, he started with the company in

Koeller Berry

1952 after a short stint with Sherwin-Williams in Chicago. He did his formal study in that city, getting a BS, MS and PhD from the University of Illinois. Koeller's research interests are varied, taking in diffusion liquids, fluid transport properties, phase equilibria, recovery of petroleum fluids from underground reservoirs. **V. J. Berry, Jr.,** co-author of the paper, is also in the Research Department of Pan American. With the company for nine years, he is currently research group supervisor in the production research division.

Thomas B. Drew, professor of chemical engineering at Columbia University, has been awarded an honorary membership in ASME for effective and faithful service to the engineering profession and the public. The citation reads in part: "pioneer in the mathematical analysis of engineering problems in fluid flow, strict adherent to fundamental scientific principles whose classic examples of applied analytical methods replaced the rule-of-thumb of the engineering art . . . early worker in defining and solving engineering design problems of nuclear reactors, eminent teacher . . ."

Drew is technical director of the AEC program at Columbia for heat transfer studies needed in nuclear reactor design. The educator has been associated with Brookhaven National Laboratory since its founding. During World War II, he was active in the Manhattan project for development of atom power. Drew, who has developed many processes for the study of heat transfer, also holds the William H. Walker Medal from A.I.Ch.E.

Other Honorary memberships in ASME, the organization's highest distinction, are held by: Dwight Eisenhower, Herbert Hoover, James H. Doolittle, Lord Weir, Ralph Flanders and Charles E. Wilson.

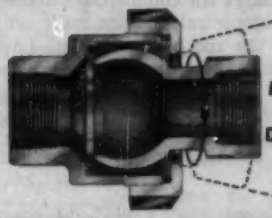
A woman chemical engineer, head of an engineering firm, will take a tour of South America as good will ambassador from the profession. **Beatrice Hicks** and her engineer husband, **Rodney Duane Chipp,** leave in March on "Project Ambassador", combined fact finding and good will tour sponsored by NSPE.

Taking an itinerary arranged by the State Department along with Washington embassy staffs, the couple will participate in informal discussions with heads of South American firms, deans of engineering schools, and American engineers. Their report will be the first step in an NSPE program to better equip American engineers to break down social and cultural barriers between the United States and other parts of the world.

continued on page 129

BARCO *Flexible* BALL JOINTS

—when you need movable joints in piping handling



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The widely travelled Mrs. Hicks is president and director of engineering, Newark Controls Company, New Jersey. She has a BSChE, Newark College of Engineering, an MS in physics, Stevens Institute, and has also taken courses in electrical engineering at Columbia.

Rodney Duane Chipp is director of engineering of ITT Communications Systems (IT&T), and is a well known specialist in electronic communications.

Hicks

Miller

Myrl E. Miller has been named manager, production engineering for the explosives operations of Olin Mathieson. Miller was manager of the company's high energy fuels operations at Niagara Falls, until he was assigned to the East Alton plants.

Cecil H. Chilton has been named chief editor of *Chemical Engineering*, McGraw Hill publication. He succeeds

Chilton

Callaham

John R. Callaham, who has moved up to editorial director of the company's Publications Division. Chilton joined McGraw-Hill in 1950 as associate editor of *Chemical Engineering*, after ten years as a chemical engineer with Socony Vacuum and Du Pont. He became senior associate in 1955 and editor of engineering developments. He is now co-editor of the upcoming revision of the Chemical Engineers' Handbook. Chilton, active in A.I.Ch.E. affairs, is a former chairman of the New York Section of the Institute. He is one of the founders of AACE, and received the AACE Award of Merit for his pioneering publications in the field of cost and cost estimation.

James W. Hemphill has joined the sales staff of Singmaster & Breyer as a pulp and paper specialist. He comes to S&B from Johns Manville Sales,

continued on page 130

Photo Courtesy Summerill Stainless Tube Div.

—absorb acid fumes and mist; remove dust; cool hot gases

Knight Fume Washers can be built to handle gases or fumes of nearly every character. The one above is removing nitric-hydrofluoric acid fumes which come off pickling tanks that are processing stainless steel tubes. The fumes enter the washer where they are neutralized with a 10% caustic soda solution. Berl Saddle packing, the operating heart of the tower, provides large liquid film areas in the gas stream. This makes for efficient fume washing with relatively small sized equipment.

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For more information, circle No. 18

People

from page 129

and the Carthage Machine Co. He was manager, Pulp and Paper Division for JM, and sales manager for Carthage.

E. L. Foerster, Sr., is now an independent consultant, after years in process development. His fields of specialization are bioengineering, waste disposal, and chemical process development. Other fields in which he will be acting as consultant are silicon manufacture, agitation, ion exchange, and by products. Foerster, a BSChE, University of Illinois, and Ch.E., University of Virginia, is located in Danville, Pennsylvania.

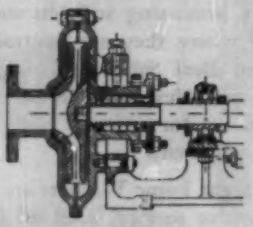
E. A. Tenthoff has been transferred to Koppers' Pittsburgh plant as senior project engineer in the Plastics Division. Tenthoff joined Koppers in 1941. He has worked at several plants, including Port Reading, New Jersey, where he was plant manager.

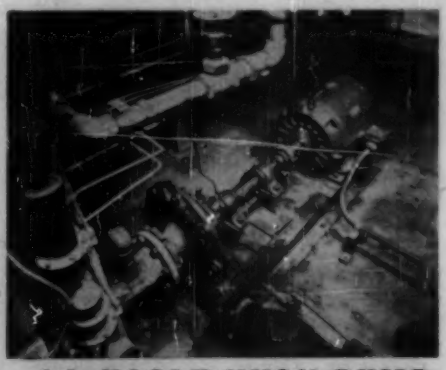
Necrology

Harvey Rowe Fife, 59. He was a senior fellow of Union Carbide Chemicals at Mellon Institute since 1927.

Howard C. Parmelee, 85, editor of *Engineering and Mining Journal* for eleven years until his retirement in 1944. Prominent in the chemical engineering profession since its inception, he was secretary of A.I.Ch.E. from 1927-29. Previous to that, as chairman of the Institute Committee on chemical engineering education in 1922, Parmelee helped formulate the accreditation program which was later adopted by the entire engineering profession. He also helped launch the chemical engineering series of texts and reference books which provided the first coordinated book literature in the field. This was in his post as chairman of a committee of prominent educators and industrialists. Parmelee was, for five years, up till 1933, vice president and editorial director of McGraw-Hill Publishing. A former president of the American Electrochemical Society, he also had been a consulting chemist and a chemist in industry.

BARGAIN HANDLING OF CORROSIVES





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FOR ABUSIVE APPLICATIONS EXCLUSIVELY

Chemical plants have found the Nagle "KC" pump a real bargain when it comes to handling corrosives. It's a pump you don't have to replace. Pump shown is performing splendidly for a Michigan processing plant. Nagle also builds horizontal and vertical shaft pumps for handling abrasive mixtures or hot solutions such as molten salt or sulphur. Write for Nagle Pump Selector. NAGLE PUMPS, INC., 1255 Center Ave., Chicago Heights, Ill.

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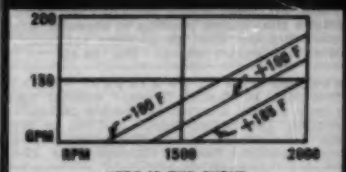

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SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER — B.S. Ch.E., 1941. Broad experience in plant start-up, design review, technical support to production, pilot plant operations, economic evaluations, technical writing. Five years' supervisory. Desire responsible, challenging assignment with expanding chemical manufacturer. Box 7-12.

PLANT MANAGER OR PROJECT MANAGER—Aggressive, hard hitting, M.S.Ch.E. with twenty years' of plant management, construction engineering project management, process engineering management. Experience in petroleum, fermentation solvents, pharmaceuticals, fine chemicals, synthetic organics, high-energy fuels, dyestuffs. P.E. Box 8-12.

CHEMICAL ENGINEER—Interested in semi or plant production after twelve years' in bench, pilot, and semi works refining and petrochemical development. Nine years' of supervisory experience. Box 9-12.

CHEMICAL ENGINEER — B.Ch.E., age 39. Fourteen years' aggressive experience, solid foundation in unit operations and equipment application. Had responsible charge of production, pilot plant, development, and shipping. Seek greater challenge — prefer south or west. Box 10-12.

GRADUATE CHEMICAL & MECHANICAL ENGINEER—Many years' experience, planning, directing development, applied research, process engineering, design of commercial plants, management experience. Fluent French, German. Some Spanish, Swedish. Free to relocate. Box 11-12.

EXPERIENCED ENGINEERING AND MANAGEMENT EXECUTIVE—30 years' supervisory and executive positions with two major companies in production, planning, purchasing, construction and product development. Limited foreign experience. Box 12-12.

CHEMICAL ENGINEER—Offers broad experience in new product development, engineering project management, top level staff planning and evaluation of business opportunities. M.S.Ch.E. Age 46. Box 13-12.

C. P. I. MANAGEMENT — Chemical Engineer available for challenging position. Responsible supervisory experience Development, Manufacturing, Staff. Organic, Inorganic, Polymer, Synthetic fibres, Electrochemicals, Pigments, Technology, Preparation, Presentation Technical-Economic Reports, Industry, Government client negotiations, Project Liaison. Box 14-12.

CHEMICAL ENGINEER—B.S. Ch.E., 1949. Ten years' experience in development and production, including heavy experience in new plant start-up and trouble-shooting. Interested in better opportunity and more responsibility. Box 15-12.

CHEMICAL ENGINEERING EXECUTIVE — Former plant engineer, director of engineering. Staff positions to top management. Versatile, broad background. Strong in Economics. Human Relations. M.S.Ch.E. Eighteen years' experience. Now in east. Present salary $13,500. Box 16-12.

CHEMICAL ENGINEER — B.S.Ch.E., also B.S. Chem. Ten years' diversified experience, process engineering, production and technical service mostly petroleum field. Seek challenging position in process engineering or production with chemical manufacturer. Will relocate. Box 17-12.

ENGINEER—B.S.Ch.E. '56. Twenty-six, married, experienced in evaluation of labor, packaging, production methods; incentive plans. Am ambitious, capable and responsible. Desire challenging position in manufacturing with medium sized progressive company in Midwest. Salary $6,000. Box 18-12.

DEVELOPMENT ENGINEER — B.Ch.E., M.S.Ch.E. 36, family. 3 years' nuclear R&D. Liquid metals, slurries, pilot-scale design, operation. Desire responsible position in process development. Goal: Technical management. $9,000. East of Chicago. Box 19-12.

VICTIM OF MERGER OFFERS—Thirty-one years, of diversified production, process development, design, administrative and consulting experience, principally in paper, food and agricultural chemicals. Box 20-12.

CHEMICAL ENGINEER—Ten years' diversified experience in process & project design, R & D, and economic evalaution in petroleum & petrochemicals. Desire eastern location. Present salary $11,400 per month. Box 21-12.

SITUATIONS WANTED

continued from page 132

CHEMICAL ENGINEER—B.S. 1954. Experience in petroleum, petrochemical and chemical fields includes: process design, economic analysis, plant start-up, technical service to operating department, and technical sales. Desire position at supervisory level in process design with progressive, expanding company. Box 22-12.

CHEMICAL ENGINEER—B.Ch.E., 1948. Eleven years' progressive experience in applied research and process development of inorganics and petrochemicals. Seek process design or development position. Box 23-12.

INDUSTRIAL MANAGER — B.Ch.E — P.E. & graduate work, capable of making decisions and assuming responsibility, used to working under pressure, desire management level position with future, salary $13,500. Box 24-12.

CHEMICAL ENGINEER—B.S.Ch.E., 1952. Eight years' broad experience in development, plant construction, start-up & production as production supervisor. Age 41. Family. Keenly interested in responsible Human Relations and/or management position. South preferred. Box 25-12.

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PROCESS DEVELOPMENT ENGINEER—M.Ch.E. with fifteen years' of experience in process development and process engineering, particularly in chemicals and polymers. Line and staff assignments at management levels. Desire related activity with progressive company. Box 27-12.

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AFTER—spending nine years' rounding my background R & D, Economics, Process Design, I am now looking for a technical management or forward planning position. P. E., M.Ch.E., marketing and management graduate training. Age 30. Box 30-12.

M.Ch.E. 1951—P.E., with fifteen years' research, process development, pilot plant, plant engineering, production and process design experience. Project management and evaluation. Plastics, polymers, coatings, organic chemicals. Desire position where capability and versatility count. $10,000 minimum. Box 31-12.

CHEMICAL ENGINEER—M.S. Ch.E., professional license. Age 30. Five years' experience in bench scale and glassware research and development of organic chemicals. Desire similar position in south or southwest. Box 32-12.

SEEK TEACHING POSITION—Ph.D. Chemical Engineer, professionally registered, with ten years' diversified industrial and teaching experience, desire professorship in a Western institution. Box 33-12.

SPACE R & D WANTED—MIT '47, B.S. Chem.Eng., Army engineer; twelve years' diversified R & D assignments: organic, inorganic, oxidation, high temperature, metallurgy, process design & liaison. Age 37, $12,000; exact, conscientious, imaginative. Rocket propulsion test or development preferred. Box 34-12.

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SITUATIONS WANTED

continued from page 133

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CHEMICAL ENGINEER - STATISTICIAN — Forty-three years old. Nineteen years' experience pilot plant research and development. Six years' concurrent statistics teaching experience. Seek job in New York, Philadelphia area with some free time for academic work. Box 38-12.

TECHNICO—Economic position. B.Ch.E., now taking M.B.A. Ten years' diversified experience in technical service, economic evaluation, planning and capital justification in petroleum supervision. Age 35, family. Desire challenging position with aggressive company—$12,500 plus range. Box 39-12.

CHEMICAL ENGINEER—M.S. Ch.E., P.E., age 41. Fifteen years' experience in process and plant design; product and process research and development; technical and economic feasibility. Good knowledge of engineering science plus sound appreciation of profitability. Desire responsible position with growth potential. Box 40-12.

SENIOR ENGINEER—Age 45, P.E. Twenty diversified years' design, project, automatic control, plant erection, start-up, foreign work, contracts on petro-chemical plants. Seek challenging staff or consulting position. Northeast, north central or foreign. $15,000. Box 41-12.

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Positions Available

New York Office

ENGINEERS for a development engineering department of a company manufacturing a complete line of mechanical packings. (a) B.S. in chemical or mechanical engineering or chemistry, with up to three years' experience in the mechanical goods field with either compounding or processing experience for molded, extruded and calendered products. (b) B.S. in chemical or mechanical engineering, with three to five years' experience in design, production or application oil seals. (c) B.S. in chemical or mechanical engineering, with three to five years' experience in design and application of metal packings. (d) B.S. in chemical or mechanical engineering, with three to five years' experience in design, production or application of mechanical seals. Salaries open. Location, upstate New York. W8216.

HEAT EXCHANGER RATING ENGINEERS, B.Ch.E. or B.M.E., with two to three years' experience for thermal and preliminary mechanical design for heat exchanger fabricator. Salary, $6600-$7200 a year. Submit resume of education and experience. Location, northern New Jersey. W8183.

PURCHASING ENGINEER, preferably chemical engineering graduate, with at least five years' experience covering purchase of chemical processing equipment. Salary, $9000-$11,000 a year. Location, New York, N. Y. W8152.

SALES APPLICATION ENGINEERS, B.S.-M.E., B.S.E.E. or B.S.Ch.E., with one to three years' prior instrument and industry experience of a general nature. Will reply to customers' inquiries, provide sales assistance and further develop projects of established feasibility, for instrument manufacturer. Salary, $6420 a year minimum. Location, Philadelphia, Pennsylvania. W8145.

PROCESS ENGINEERS, graduate chemical engineers, oriented to manufacturing, with four to eight years' experience, to be responsible for administrative controls, assure production quality, establish and maintain production specifications, investigate customer complaints, general implementing of transfer of new products from research, development to production. Company manufactures industrial plastics. Salary, $6000-$10,800 a year, depending upon experience and background. Company will pay placement fee. Location, Delaware. W8140.

AGGLOMERATION ENGINEER, B.S. or M.S. in mineral, metallurgical or chemical engineering with three to five years' in sintering and pelletizing preferably of iron ores or concentrates. Laboratory, pilot plant and plant operations experience desirable; for process and economic studies of new and existing processes. Location, western Pennsylvania. W8130.

SENIOR PRODUCT ENGINEER, mechanical or chemical engineering graduate, with at least five years' product design, development and processing experience in plastic, resins, adhesive or rubber fields. Salary, $8000-$10,000 a year. Location, Ohio. W8129.

PROJECT ENGINEER, chemical or electrical graduate, with a minimum of ten years' broad general experience. Will have responsible charge of small engineering office, including administrative, in factory and laboratory of electro-chemical equipment manufacturer. Salary open. Location, Philadelphia, Pennsylvania, area. W8125.

SENIOR RESEARCH ENGINEER, Ph.D. in chemical engineering, with five years' experience in heat and mass transfer fluid flow and high vacuum, to design, build and operate pilot plant to produce material for consumer and market tests for various products such as fruit, vegetables, etc. Determine the needs, material cost and general economics of a commercial size unit and be able to set it up. Salary, $9000-$10,500 a year. Location, Midwest. W8123.

SALES ENGINEER, chemical or mechanical graduate, with from two to five years' experience in chemical process equipment, covering evaporators, dryers and pressure vessels. Salary plus expenses. Territory, New York Metropolitan area. W8114.

CHEMICAL ENGINEERS. (a) Junior Chemical Engineer or Chemist with experience for laboratory and development work on electrochemical products. Salary, $6000-$6500 a year. (b) Chemical Engineer with about three years' experience in electro-chemical or electrometallurgical product fields. Salary, $7200-$7500 a year. Location, Westchester County, New York. W8108.

CHEMICAL ENGINEER, Absorbent Research, 25-35, B.S. or M.S. degree, with experience and/or training and interest in the area of physical chemistry, thermodynamics. Will direct and conduct research in the field of absorption refrigeration, particularly with respect to the thermodynamic, physical and economic suitability of organic and inorganic absorbent-refrigerant combinations. Salary, $6000-$8500 a year. Location, Midwest. W8104.

CHEMICAL ENGINEERS, CERAMISTS OR CHEMISTS, young, graduates of recognized schools, for work along research and sales service lines. Up to five years' experience, particularly in the field of cement, heavy ceramics or the stone and lime industries desired. Location, South. W8051.

PROJECT ENGINEERS, degree in mechanical, electrical, chemical or metallurgical engineering, from 27, with at least five years' design, and development experience on products of a small close tolerance nature for use in hydraulic and pneumatic systems. Familiar with Military standards and production procedures. Should have previous experience in machine shop and on drawing board. Work will include design of new products, re-design and determination of new applications, feasibility studies. Activities will range from inception of ideas through design, model making, testing and marketing. Salary, $8100-$9367 a year. Location, vicinity of Newark, N. J. W8067.

RESEARCH ENGINEERS. (a) Research Engineer, Ph.D., M.E. or Chemical Engineer, 28-40, experienced or trained in heat transfer, thermodynamics or fluid mechanics for work in areas such as thermal radiation, convection, boiling, conduction, flow-induced noise, two-phase flow, multicomponent mixing and separation. Will guide research programs, analyze experimental results and consult on advanced engineering problems associated with steam generators, nuclear components and other heat transfer equipment. Salary, $9600-$11,400 a year. (c) Chemical Engineer, M.S. or Ph.D., with experience in experimental research to interpret and correlate results of various experimental R & D programs. Should have broad background in basic science and engineering. Typical projects involve high temperature inorganic chemistry, thermochemical calculations, mass transfer operations and heat transfer from gases by radiation. Salary, $8900-$10,200 a year. Some travel on all positions. Must be U.S. citizen on A. Company pays placement fees and relocation expenses. Location, Ohio. W8041.

MANAGEMENT PERSONNEL. (a) Manager of Product and Process Development in an electro minerals division, graduate chemical or metallurgical engineer, with experience in mineral dressing, ferrous metallurgy and arc furnace technology. Salary, $10,000-$12,000 a year. (b) Manager of Research for a bonded abrasives division, to establish and operate a small research group: Ph.D. in chemistry, physical chemistry, ceramics or allied fields, with some experience in working and supervising in applied research. Salary, $10,000-$12,000 a year. Location, New York State. W7346.

SALES ENGINEER, graduate chemist or chemical engineer, young, preferably with several years' experience with fatty acids, tall oil or turpine products. Salary, about $7800 a year. Territory, Michigan, Ohio, Indiana and Kentucky. W7618.

Chicago Office

RESEARCH CHEMICAL ENGINEER, graduate chemical engineer, with strong leaning toward mechanical applications of chemical process equipment. Will do considerable amount of field contact work and conduct field trials for coagulants. Particular duties will be to bring into the lab an understanding of field conditions. Should have a strong personality and somewhat sales oriented, but at the same time willing to work in research laboratory. Some technical sales experience is highly desirable. Salary, to $8400 a year. Employer will pay placement fee. Location, Chicago. C7799(b).

RESEARCH ENGINEER, B.S., M.S., or Ph.D., with or without experience for applied research on chemical treatment of metals used in the fabrication of articles. Steel, zinc, aluminum and their alloys are the most important. Chemical treatment forms coatings on the surface of the metal which are used as base for organic coatings, base for ceramic coatings, aid to cold forming wear resistant and corrosion resistant. The work will be largely in the inorganic field with appreciable physical and organic chemistry involved. Salary open. Location, Michigan. C7791.

ENGINEERS. (a) Chemical Engineer, B.S. or equivalent, 30-40; five or more years' experience in chemical production and maintenance work. Duties: Production planning and coordinating work distribution, raising performance standards, methods, improvement, cost reduction, safety and determining of optimum operating techniques. Maintenance assignments including reports, equipment specification and rearrangement, drawings, costs and consultation on mechanical problems. Will report to Plant Manager and be responsible for assignments in production and maintenance. Company is engaged in research, development and production of chemically compounded products. Salary, $9000 a year, plus good fringe benefits. Employer will pay placement fee. Location, Chicago. (b) Project or Process Engineers, graduate chemical engineer or chemistry, to 35; five or more years' experience in project or process engineering in chemical industry. Experience in plastics or latex desirable. Must be familiar with unit operation and processes. Should be able to prepare technical reports and operating instructions. Will prepare estimates on layouts, designs and/or modify equipment to meet production needs, select process equipment; also supervise installation and testing of process equipment. Will report to Assistant Chief and be member of plant engineering department. Salary, $9000-$10,000 a year. Employer will pay placement fee. Location, southeastern United States. C7757.

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SITUATIONS OPEN

continued from page 134

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SITUATIONS WANTED

continued from page 134

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CHEMICAL ENGINEER — B.S.Ch.E., twenty-five years' experience in fine and heavy chemical manufacturing. Includes responsible production and development management. Interested in management or administrative position in chemical or allied industries. Salary $14-16,000. Box 47-12.

CHEMICAL ENGINEER—37, M.S.Ch.E., P.E. Three and one-half years' Project Engineer. Engineering, economics, design, appropriation studies, construction. Five years' development supervisor, four and one-half years' research. Desire responsible position as project manager or in plant engineering. Box 48-12.

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Advertisements in the Classified Section are payable in advance at 24c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. **Members of the American Institute of Chemical Engineers in good standing are allowed two six-line Situation Wanted insertions (about 36 words each), free of charge a year. Members may enter more than two insertions at half rates.** Prospective employers and employees in using the Classified Section generally agree that all communications should be acknowledged as a matter of courtesy but recognize circumstances where secrecy must be maintained. Answers to advertisements should be addressed to the box number. Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

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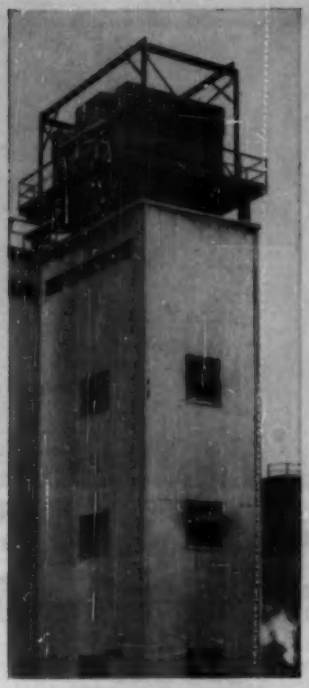

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News and Notes of A.I.Ch.E.

An Accounting of Stewardship. For a number of years I have made the December column of News and Notes an accounting of stewardship to the members of A.I.Ch.E. Throughout the year the column aims to keep members informed of the actions of the Council, the work of the committees and the Local Sections, and other matters of professional interest; but at each year end it is well to pause to reflect where we have been, what we have accomplished, and where we are going. Last year, being the Fiftieth Anniversary, was the culmination of many activities and the laying of groundwork for new ones. 1959 saw continuing progress by chemical engineers, and the profession itself, I believe, is on a firmer basis than ever before.

Dominating the achievements for the year was the news on July third from the United Engineering Trustees that the American Institute of Chemical Engineers had **achieved its quota of $300,000** in the United Engineering Center Building Fund Campaign. The A.I.Ch.E. was the first—and at this writing is still the only—one of the engineering societies to achieve its goal. This is a matter of which the membership may well be proud, and we hope that those members who read these words and who have not given will contribute to this most necessary engineering home. Ground was broken for the building on October first, and the building is expected to be completed some time late in 1961.

Chemical Engineering Progress gained a **new editor,** F. L. Resen. The *A.I.Ch.E. Journal* increased its subscription price to members and nonmembers, and for this increase it is hoped to bring to the members **more pages of technical material.** The Symposium Series of the A.I.Ch.E. had an extremely active year. **Seven volumes** resulted from the accumulation of papers through the Golden Jubilee Year, when many of our publication activities had to be suspended until the special Jubilee volumes were out of the way. The series, now containing twenty-nine books, has for eight years been a successful method of accommodating the ever-continuing flow of technical papers for chemical engineers which their professional society is expected to publish. This year, also, we made available the **first A.I.Ch.E. technical manual.** On bubble-tray design, it has sold very well to the membership and is an outstanding contribution to the technique of calculations in distillation columns. The A.I.Ch.E. Standard Equipment Testing Procedures for **centrifugal pumps** and for **impeller mixing equipment** both came out in 1959, and we also published a **Directory and a Supplement** to the Directory to bring the committee personnel up to date. Possibly, for some of the younger statesmen, a booklet which we turned out during the year may be of some importance. It is called **"Endowing the Chemical Engineering Profession."** If you are one of those who have succeeded financially in the chemical field and wish to help the profession materially, the booklet has many fine ideas on how this may be done.

And during the year A.I.Ch.E. joined the Engineering Societies Personnel Service, an **employment service** owned by the Five Founder Societies, which specializes in finding employment for members of the professional engineering groups.

The second **Special A.I.Ch.E. Lecture** took place in San Francisco when G. E. P. Box and J. S. Hunter addressed a group of specialists on process development by statistical methods. The A.I.Ch.E. **cooperated in two meetings** other than its own—the Nuclear Congress at Cleveland and the Heat Transfer Conference at Storrs, Connecticut.

As for myself, I thank all the members for their fine cooperation and their support of the many projects that they have been asked to undertake. The members deserve not my thanks but the thanks of the profession as a whole—the thanks of the country—for seeing to it that we are a healthy and professional group publishing the necessary information to keep the American chemical industry well ahead of competition.

F.J.V.A.

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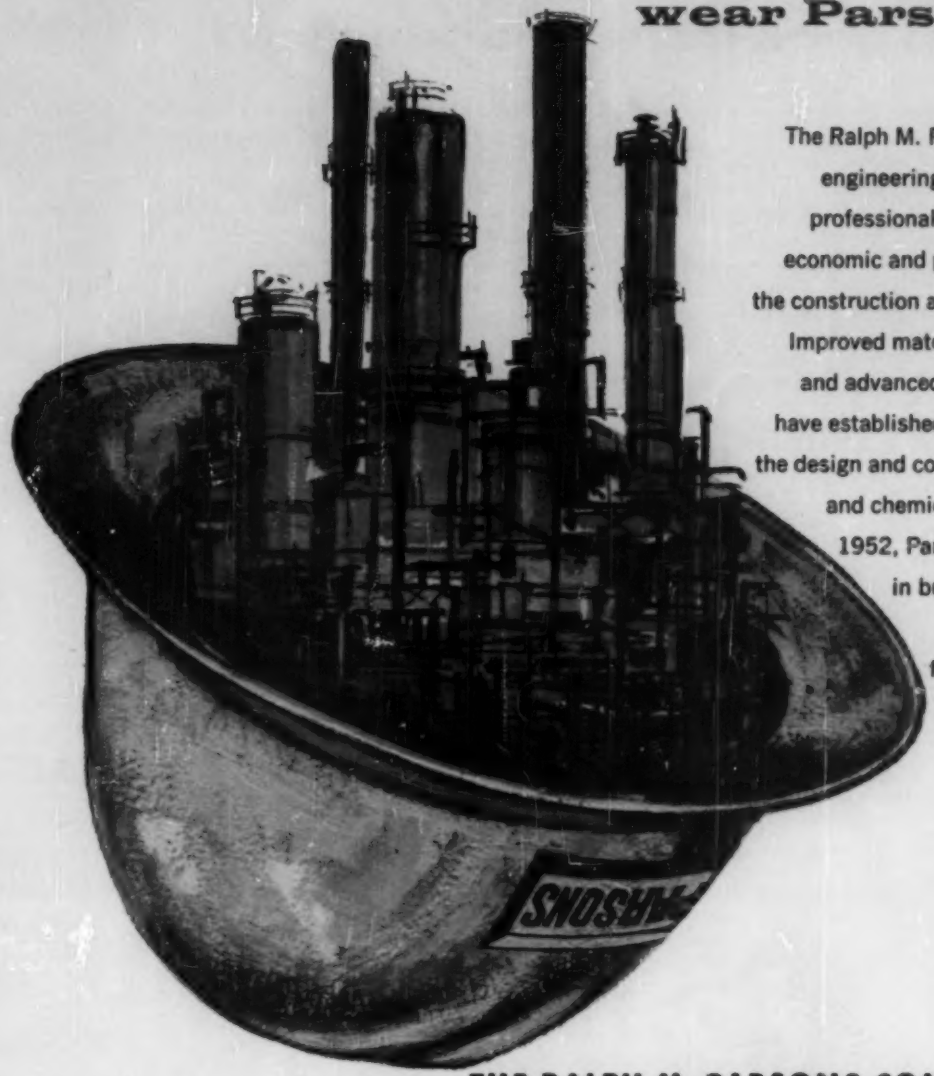

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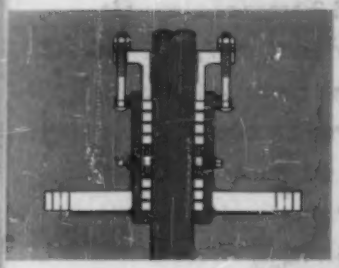

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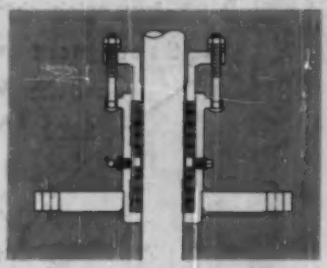

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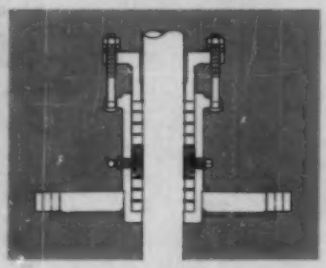

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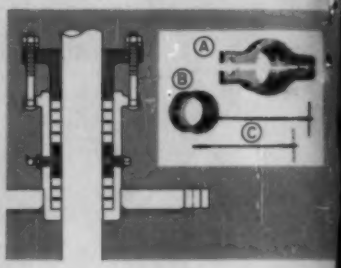

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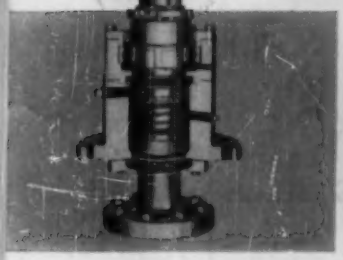
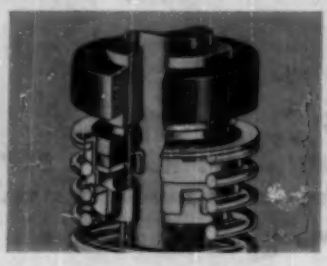
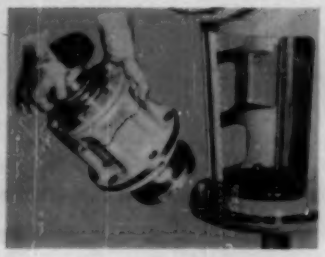


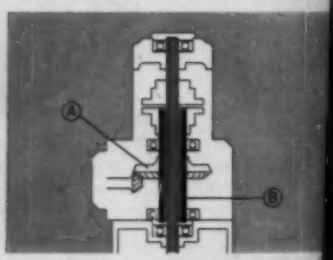
1. ELIMINATE REPACKING and adjustment with this cartridge-type LIGHTNIN rotary mechanical seal assembly, optional on all LIGHTNIN Mixers. It's saving many users thousands of maintenance dollars a year.



2. GET WIDEST CHOICE of seal designs and materials to meet your conditions: stainless steels, Stellite, Hastelloy alloys, bronze, ceramic, Teflon, etc. Handle pressures to 2500 psig and all temperature ranges.



3. REPLACE SEAL ASSEMBLY quickly, if ever necessary—without dismantling mixer or removing it from tank, and *without skilled manpower.* Seal cartridge unbolts, comes out as a unit; replacement bolts in.



4. RETAIN GEAR ALIGNMENT when changing seal. Mixer gears (A) are isolated from shaft by hollow drive quill† (B) *—cannot get out of line* when seal is removed. Shaft realignment is automatic on reassembly.

†patented

WHAT MIXING OPERATIONS are important to you? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅓ to 3 HP (B-108)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)

Check, clip and *mail* with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 199-n Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

For more information, turn to Data Service card, circle No. 54

Lightnin® Mixers

MIXCO fluid mixing specialists

*patent pending